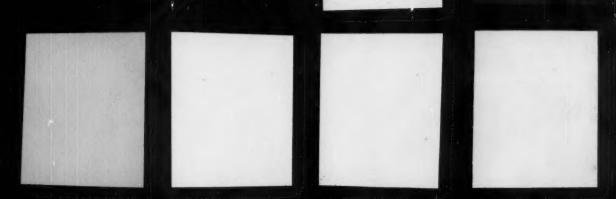
APRIL 28 1960

DESIGN

A PENTON PUBLICATION - BIWEEKLY



The Ost of Color in Plastics



Contents, Page



Thousands of ways to cut bearing costs lie in our huge stock of high-precision dies for sintered bronze or iron bearings. The world's largest inventory of dies is ready at an instant's notice to turn out the exact bearings you need . . . without the delay or expense of tooling. One more assurance of the exceptional service you can expect of Bound Brook.

BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J. Pioneer in Powder Metallurgy Bearings and Parts.

Plants at Bound Brook, N.J. and Sturgis, Mich.



NO MATTER WHAT YOU'RE COOKING UP . . . Chances are there is a ROSS valve ready!

Ross is the air valve line with the largest selection and latest advancements.

Solenoid, hand, foot, cam and air operated valves in both line and base mount models, to serve straightway, 3-way and 4-way functions. Auxiliary and special valves too.

Write for digest catalog.

Circle 404 on Page 19

ROSS OPERATING VALVE COMPANY

109 EAST GOLDENGATE AVE. . DETROIT 3, MICHIGAN





Jet fighters take off in seconds instead of minutes-even GOOD FYEAR from remote airstrips—thanks to self-contained starters that obsoleted huge, hard-to-handle storage batteries. The G.T.M.-Goodyear Technical Man-and

his colleagues had a hand in this when they developed an economical molded rubber case for the new starter cartridges. Tests proved the new rubber compound capable of sealing the breach in the face of the searing heats and pressures—even for take-offs in arctic temperatures as low as -80°F. or tropic conditions up to +160°F. What's more, the G.T.M.'s special rubber slashed the costs over earlier starter-cartridge-case materials by an amazing 85%. Illustration courtesy Olin Mathieson Chemical Corp., New York, N. Y.





practically nothing's impossible when the G.T.M. and Goodyear molded/extruded specialists go to work with rubber or plastics.

If you'd like to know more about their accomplishments-or see the incomparable Goodyear molded/ extruded plant for yourself-just write Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

Lots of good things come from

THE GREATEST NAME IN RUBBER



Frent Cever: Using only three blacks of the primary colors, artist George Farnsworth points up, by the simple technique of omission, the effectiveness of color as an appearance tool. To find out how much color can cost, see the article by A. J. Benjamin, which starts on Page 120.

Project Rover
Color in Plastics
A J. BENJAMIN—How design requirements, molding methods, material quantities, appearance considerations, and color selection influence total cost of a finished product.
Hydrodynamic Drives
R. W. BACHMANN—Part 3: Torque Converters—Characteristics of individual units, general considerations in selection, application to electric motors.
Folded Fastening
FEDERICO STRASSER—Advantages and limitations of a quick and simple method for as- sembling sheet-metal parts without using conventional fastening devices.
Simplified Vibration Analysis
AUSTIN H. CHURCH—Part 6: Beams—Methods for analysis of vibrating systems in which stiffness and mass are distributed rather than being concentrated at specific points.
Filter Materials
WALTER KASTEN—A guide to the selection and application of the most common types and forms of filtration materials currently being used.
Planetary Gear Ratios
H. REED LANGDON—Data Sheet—A table of possible gear combinations for building up the stages of simple planetary gearboxes to obtain specific reduction ratios.
Electrical Adjustable-Speed Drives
ments under varying conditions of speed and torque.



The Man Nobody Sees	119
Engineering News	6
Lockheed's "bush" plane 6 Impact simulator	30
Design Show prospects 6 Nuclear blimp	32
More about money 8 Portable ICBM tracker	34
Brazing breakthrough 10 All-nickel forming dies	36
Foam-vaporization casting 12 Isotope applications	36
NBS adhesive study 14 Orbiting X-15?	41
Semiconductor inverters 25 Colored stainless	42
Trends Meetings and Shows	
Scanning the Field for Ideas	126
Bistable magnetic cores provide pulse-actuated permanent memory—c	
centric belts increase power-transmission capacity—motor shell serves	
float to operate switch—shaped shank automatically selects the type	
tool motion—plugs in stainless steel concentrate magnet flux to actu	
switch—automatic tensioning maintains belt tension proportional to lo	ad.
D 1 1 A 11	154
Design in Action	
Wire-fabric welder positions finished mats for compact stacking—eleva	
and air bath provide shot supply for strip descaling—counterrotat	-
engines stabilize 300 plus mph salt flats racer—mechanical-memory dr	1100
stores position error on sliding pins.	UIII
	om
Tine and Techniques	om
Tips and Techniques	
Tips and Techniques Drawing formed tubing 137 Selecting components Pipe diameters 150	
Drawing formed tubing 137 Selecting components	
Drawing formed tubing 137 Selecting components 150 Design Abstracts	150 1 72
Drawing formed tubing 137 Selecting components Pipe diameters 150	150
Drawing formed tubing 137 Selecting components	172 188
Drawing formed tubing 137 Selecting components 150 Design Abstracts	150 1 72
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228
Drawing formed tubing 137 Selecting components	172 188
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228 233
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228 233
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228 233 238
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228 233 238 252
Drawing formed tubing 137 Selecting components Pipe diameters	172 188 228 233 238 252 182

IN THE NEXT ISSUE: The technician: engineering semipro? . . . revitalizing the engineering organization . . . the electromagnetic drive . . . cycle-sequence charts . . . torque-converter curves . . . creep and relaxation of plastics . . . polyhedrons . . . the least squares method . . . Special Feature—Design Engineering Show Guide.

Editor COLIN CARMICHAEL

Associate Managing Editors BENJAMIN L. HUMMEL ROBERT L. STEDFELD

Associate Editors
LEO F. SPECTOR
WILLIAM S. MILLER
SPENCER R. GRIFFITH
JAMES A. PARKS
MELVIN E. LONG
JESSE W. HUCKERT

Assistent Editors
CLARE E. WISE
THEODORE M. LEACH
STANLEY G. COOK
RICHARD A. JACOBSON
JOHN J. HOSTAK
DONALD R. DREGER
ANTHONY F. MEGRAW
JAMES J. BUNTING
JANE H. SMITH
MARIAN L. EICHAR

Art Editors FRANK H. BURGESS ROBERT L. TUFTS

EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices New York, Detroit, Chicago, Pittsburgh, Washington, London



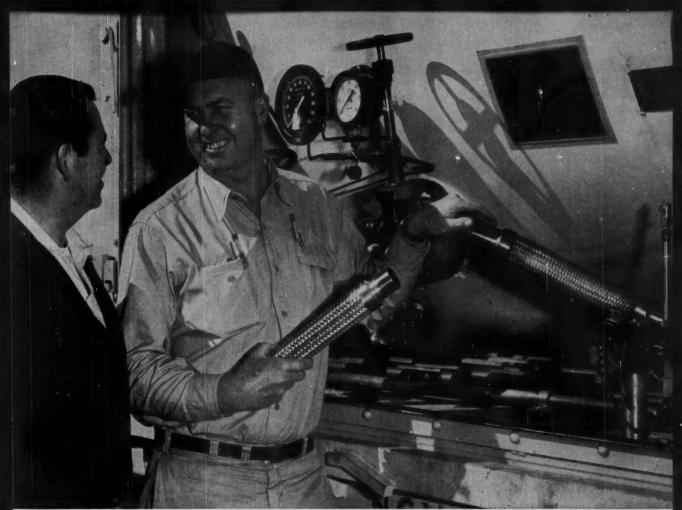
©1960 by The Penton Publishing Co. All rights reserved.

All rights reserved.

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Cansulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, \$10. Single copies \$1.00. Other countries: One year, \$25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday by The Penton Publishing Co., Penton Bidg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



Anaconda Vibration Eliminator, 11/2" 1.D. x 17", installed in liquid fill line of a 9000-gallon liquid oxygen tank installed in a boxcar by Lox Equipment Co.

When -297°F LOX hits the piping, standard Anaconda tin bronze flexible connectors absorb the shock

Flexible metal hose connections used to absorb thermal contraction and shock in piping carrying liquefied gases vary widely in size, material and design. Anaconda makes assemblies in stainless steel up to 14 inches I.D. for LOX lines in missile ground handling equipment—and other special connectors and hoses in a variety of metals down to $\frac{1}{16}$ inch I.D.

But there are many places where standard Anaconda flexible metal hose assemblies of tin bronze can do a job dependably and with economy. Lox Equipment Co., Oakland, Cal., makes unfired pressure vessels to hold liquefied gases. To protect valves and piping from stresses set up when liquid oxygen at -297°F or liquid nitrogen at -320°F begins to flow, the company has found standard Anaconda Vibration Eliminators highly satisfactory. These flexible connectors designed for damping vibration in rigid piping of refrigeration systems have the physical properties needed-the high strength, toughness, and fatigue resistance inherent in tin bronze. In fact, these properties are greater at very low temperatures-tensile and yield strength of copper and copper alloys are materially higher at -300°F than at room temperature. Working pressure of 60 psi is no problem, as standard VE's are designed for applications up to 300 psi-in some sizes up to 500 psi.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are

constantly working with design engineers on flexible connectors and hose to meet new problems. They may recommend a standard unit or help in the design of a special unit. For information on standard units or engineering assistance, write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.



ANACONDA®

DESIGN

ENGINEERING NEWS



Hard Worker for a Bush Job

High-lift Fowler flaps and a "blown" engine will give Lockheed's new Model 60 the exceptional takeoff performance it needs when operating from Mexico's hot, high-altitude airports. Designed as a hard-working "bush" airplane, the light single-engine craft is scheduled for production by Lockheed-Azcarate, S.A., a partnership between Lockheed Aircraft International and a group of Mexican business leaders.

Useful-load figures for the LASA 60 are impressive: Up to 1500 lb total—with provisions for six people. Alternate configurations include a two-patient aerial ambulance with attendant, sprayer and duster models, and float or ski gear options. A Continental fuel-injection supercharged engine gives the plane top speed of 165 mph (at 10,000 ft), gets it over a 50-ft obstacle in 1045 ft (at 3532 lb gross weight).

Design Show Attendance Will Top 20,000

NEW YORK — Engineers from all parts of the U. S. will gather at the New York Coliseum May 23-26 to take in the Design Engineering Show and the concurrent ASME Design Engineering Conference. Virtually every large manufacturing company in the country—over 400 in all—will exhibit new products, processes, and services at the four-day exposition, and advanced registrations and inquiries hint that attendance will top 20,000.

Brand new in 1956, The Design Show has grown every year at an unprecedented rate; last year it was one of the largest expositions held in the U. S., and this year it promises to be still bigger. Products and displays will exceed \$10 million in value, with over 15,000 products be-

ing exhibited—including mechanical, electrical and electronic components; metals and nonmetallic materials; fasteners, finishes and coatings; hydraulic and pneumatic components; power transmission research and testing equipment; and engineering department equipment and services.

Eight technical sessions highlight the Design Conference. Theme this year is the application of space-age theory and techniques to the design of products for home and factory. The sessions break down like this:

• How design principles, relationships, and formulas developed for nuclear and space technology can

be applied to better the design of commercial products (May 23).

• Methods and interpretation of

answers to reliability predictions and the meaning of reliability requirements (May 24).

• New methods of joining and forming metal parts (May 24).

• Hydraulic equipment designed for "extreme-service" frontiers (May 24).

• Engineering problems associated with computers in the control field (May 25).

 Properties of high-strength steels and composite materials (May 25).

 Design recommendations for miniature and subminiature components (May 25).

• Uses of computers in design (May 26).

On May 23 and again on May 26, one technical session will be offered, but on May 24 and 25 Show visitors will have to choose between one of three sessions.

... Fluid Power NEWS

REPORT
NO. 11,303
SPEED-COST
"BREAK-THRU"
FOR GLASS
PACKAGING

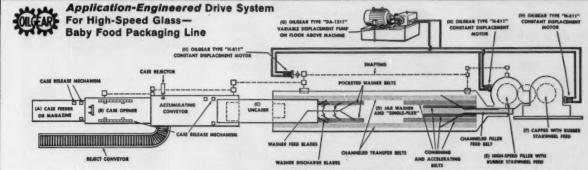
From Oilgear Application-Engineering Files

HOW OILGEAR SYSTEMS on Gerber's Integrated Glass Lines BOOST OUTPUT—CUT COSTS

USER: Gerber Products Company, Fremont, Michigan; Rochester, New York; Oakland, California

DATA: To sharply reduce breakage, jam-ups, down-time, and labor costs in filling glass baby food jars at higher speeds, Gerber's Engineering Research Department developed the first fully integrated, high-speed machine for packaging foods in glass economically, under completely automatic control. Drive Requirements for this multi-unit machine were outlined as follows: 1. Complete synchronization of the seven integrated units through three drives—at the Uncaser, Filler, Capper. 2. Positive, precise, remote pneumatic

control of operating speed that is instantly, infinitely variable from very slow to top speed while the machine is running. 3. Controlled acceleration and deceleration to prevent jars from tipping and jamming, eliminates spillage, reduces machine strain. 4. Compact, for maximum work area. 5. Independent operation of Filler and Capper drives to facilitate cleaning. 6. Trouble-free, dependable, long-life operation, immune to frequent sanitary washdowns, fully enclosed to prevent food contamination.



solution: An Oilgear "Any-Speed" Drive, consisting of a Type "DA-1211" variable displacement pump and three Type "H-811" constant displacement motors—powers all elements of "The Gerber Integrated Glass Lines" to meet and exceed originally specified drive requirements. For maximum work area around the "Glass Line," prevention of possible food contamination, and use of an economical electric motor, the Oilgear "Power-Pak" is located on a different floor of the building. A compact control panel located at the Filler enables the operator to start, stop, jog, and instantly vary speed of the entire machine through an infinite range while the machine is running—thereby obtaining maximum efficiency for the consistency of the food being filled. The drive system automatically synchronizes the speed of all seven machine units. Operating speed ranges from 550 to 650 jars per minute—depending entirely upon the products being filled ... an increase of up to 23% over former conventional glass packaging methods.

GERBER REPORTS—"The major advantages of this newly developed equipment are: less shock and scratching of jars, which reduces damage; substantially higher speeds: more thorough washing; lower maintenance cost and automatic control of all segments of the line."

Due to the smooth, cushioned application of power, even at higher speed, reduced glass damage and the resulting reduction in downtime, maintenance and labor costs with this Oilgear-powered, Gerber-designed machine, an expanded installation program of these "Integrated Glass Lines" is now under way at all Gerber plants.

Circle 407 on Page 19

HOW IT WORKS. One man feeds 24-jar cases—flap side up—onto Case Feeder (A). Timing mechanism synchronizes delivery to Case Opener (B) where carton flaps are lifted out. Unopened flaps or inverted jars cause automatic case rejection. Normal cases proceed to Uncaser (C) where the case and divider panels are pushed down and away from the jars. Uncaser deposits jars on transverse-channeled conveyor platens. Blades slide jars from channeled platens into pocketed belts which hold jars inverted through Washer (D). Jars are plowed from washer belt pockets to transverse-channeled combining and accelerating belts—moving 350 to 400 jars per minute . . . are then "shuffled" into the "Single-Filer"—550 to 650 jars per minute on a channeled belt to Filler (E). Rubber starwheels minimize breakage in feeding the 25-pocket Girdler Filler (E), and 16 twin-head Anchar-Hocking rotary Capper (F) . . . both autombuilt for Gerber with center-to-center jar spacing for positive, smooth glass transfer between units. Smooth synchronization, cushioned acceleration and deceleration provided by the Oilgear Drive and Control System, combined with no jar-to-jar contact make possible the almost noiseless higher speeds and virtual elimination of glass damage . . . for if even a single jar or bottle is broken in food or pharmaceutical operations, a complete and costly shutdown, cleanup and inspection of the packaging line by quality control personnel is required.

"PLUS" features of this Oilgear Drive and Control System are: dual, automatic, built-in hydraulic and electric overload protection—stops the machine in event of jamming or malfunction . . . automatic hydro-dynamic braking . . . direct torque reading at the control panel . . . constant pressure and flood lubrication with continuous power fluid filtration . . . complete flexibility for location of drive and control components . . . fast, easy installation . . . standard drive and control components sealed against washdowns . . . lower power consumption—using only power in proportion to work performed. There are many more—but these alone should be sufficient proof why designers and builders of machinery are turning to Oilgear, and say "for the lowest cost per year—it's OILGEAR!"

For similar practical solutions to YOUR linear or rotary Controlled Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems
1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

More About Money: Reports from Campus and Capitol

ANN ARBOR, MICH.—"The general demand for fledgling engineers is higher than last year, and salaries, well past early estimates of a 1.8 per cent increase, are up 5 per cent," according to a report just issued by the University of Michigan's engineering placement office.

The U-M report sets average monthly earnings for bachelor-degree holders at \$535, compared to last year's \$508 average. Job seekers holding masters degrees are being offered \$621—up from \$601.

Again in 1960, the greatest demand is for electrical engineers, whose starting salaries will average \$547. EE's have held the same enviable position for the past several years.

Gov't Needs New Approach . . .

Washington—An across-the-board salary boost will not get at the heart of the Government's most serious personnel problem—recruiting and retaining an adequate engineer/scientist force. This is the opinion of Paul H. Robbins, executive director of the 52,000-member National Society of Professional Engineers.

He told members of the House

Committee on Post Office and Civil Service that what is needed is "a salary system attuned to changing market conditions and which would permit the Federal Government to adjust salaries promptly and effectively . . ." Calling attention to an NSPE survey showing that salaries for Government engineers lagged considerably behind industry levels from 1952 through 1958, Robbins said that the spread increased appreciably in 1959.

He outlined five steps that might help Congress develop equitable salary legislation:

 Assign authority for setting starting rates to agency heads.

 Recognize the exceptionally high demand for certain engineering and scientific specialists. Set salaries at appropriate and competitive levels.

 Establish procedures for quickly adjusting pay scales as nongovernmental rates for comparable employees change.

 Recognize—with salary adjustments—outstanding merit, job performance, and responsibility.

• Eliminate artificial distinctions between "super grades" (GS-16, 17, and 18) and the other 15 grades of the General Schedule.

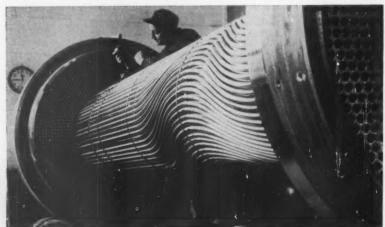
Topics

No air in the spare until the tire is needed saves space in the trunk. Under experiment at Dunlop Tire & Rubber Corp. is a less-than-an-inch wide tubeless tire which is inflated from a flask of compressed air just before use. The tire is attached to a thin steel disc drilled to match the car's wheel stud spacing. The skinny wheel will reportedly travel "a considerable distance" and not make much difference in a car's handling.

Favorite snapshots could be those taken by a robot bank teller which photographs deposits, makes one print for its employer, and hands another one to the depositor to keep as a receipt. The machine stays within the law by partially covering the bills. Reflectone Electronics Inc., builder of the "teller," suggests that it could be used to provide 24-hour banking service, receive Christmas Club deposits, receipt utility bills, and do other routine jobs.

A good memory replaces a key in opening an electrically operated combination door lock designed in Great Britain. The lock has an outer panel with 12 buttons or switches; depressing four of these two-by-two in the right order and within a preset space of time, will open the lock by means of relays. An alarm sounds if the wrong buttons, or the right buttons in the wrong sequence, are pressed. The lock has over 4300 possible combinations.

Nineteen Miles of Cooling



Three sedium heat exchangers with miles of curved tubing are being built for the Enrico Fermi reactor at Lagoona Beach, Michigan. The stainless steel tubes, supplied by Allegheny Ludlum Steel Corp., are bent into special compound curves to accommodate differences in thermal expansion. A unique feature of the exchanger design is that each tube bundle can be removed from its shell without cutting. The bundles have a gasketed joint which separates tube-side from shell-side sodium. Ten-in. long springs hold the seals in place.

Top German Kinematicians Will Lecture at Yale

Two of Germany's most eminent design engineers will join members of the Yale University faculty during the academic year 1960-61. The men and their specialties:

Professor Rudolf Beyer, of Munich, will teach Analysis and Synthesis of Mechanisms, with emphasis on plane and three-dimensional linkages.

Professor Kurt Hain, of Brunswick, will teach a continuation of this course, entitled Design of Mechanisms, in the second (Spring) semester.

Messrs. Beyer and Hain are not strangers to the U. S. Both have presented papers at the Mechanism Conferences, co-sponsored by Purdue Univ. and Machine Design.



"ALCOA ALUMINUM OFFERS A CHOICE OF TWO SCREW MACHINE STOCK ALLOYS FOR STRENGTH: 2017 AND 2024!"

Precision-made, high-volume screw machine parts cost less in aluminum

Here are the strongest of all Alcoa® Aluminum screw machine alloys. Both will give you superb machinability. Both will give a fine, clean finish. Alcoa Alloy 2017-T4 or -T451 is exceptionally good for deep drilling operations. Alloy 2024-T4 or -T351 offers high shear strength . . . which makes it a popular choice for fasteners and fittings. These alloys will give three times as many parts per pound as other, heavier metals, raise your profits by cutting your over-all unit costs.

Ask your Alcoa distributor or Alcoa sales office for your free Alcoa Conversion Calculator... which makes cost conversions from brass to aluminum and computes costs quickly... and your free Alcoa Screw Machine Stock Estimating and Operating Data Book, a comprehensive, easy-to-use book of technical data on aluminum screw machine stock. Get full information on other Alcoa alloys: 2011-T3 or -T8 for faster cutting, 6061-T6 or -T651 for superior finishes, excellent joining charac-

teristics and extra corrosion resistance. Aluminum Company of America, 840-D Alcoa Building, Pittsburgh 19, Pennsylvania.

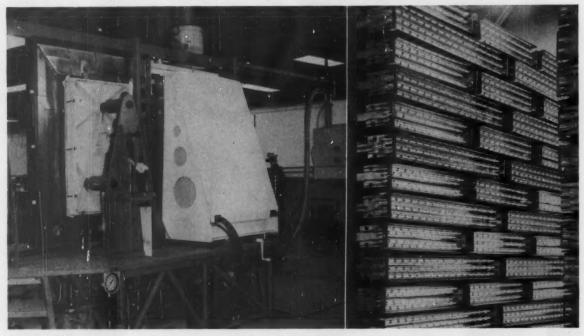
GET ALL THESE BONUSES WITH EVERY ALCOA ALLOY:

- 1. Wide range of stock sizes for important price advantages.
- Guaranteed market for up to 60 per cent of your Alcoa Aluminum turnings and borings.
- Extensive mill and distributor inventory to meet all requirements.
- 4. Chamfered ends at no extra cost.
- Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).



SCREW MACHINE STOCK

Infrared Brazing: Breakthrough for the Stainless Flight Era



precision honeycomb

by tailored temperatures

and split-second timing

Stainless-steel panels are first mounted in air-tight envelopes, then brazed and moved to adjacent chill forms (left). Switching the part from braze to chill position takes about 1 sec. Carriage frame supporting the enveloped part is

covered with gold (high reflectivity) shields to prevent overheating of the structure surrounding the brazed area. Banks of radiant quartz lamps (right) provide controlled heat, can be energized separately or in combinations.

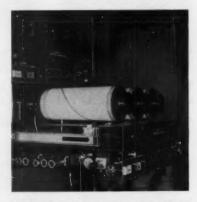
HAWTHORNE, CALIF.—Stainless-steel aircraft and space vehicles may soon gain added strength, yet cost less to build. A new honeycomb-brazing technique — developed by Norair Div., Northrop Corp.—cuts back 3 to 12 hour furnace-brazing times to a matter of minutes. Work can be brought up to temperature and cooled in seconds.

Electronically controlled radiant quartz lamps provide temperatures up to 6000 F. Honeycomb panels, hung vertically on conveyors and surrounded by radiant lamps, are evenly heated, even when they're nonsymmetrical, curved, or their thickness varies. Before heating, the panels are "painted" with both gold and black colloidal suspensions—black in areas needing lots of heat, gold in areas needing little heat. Emissivity of any part of the surface area can be varied from 0.04 to 0.96 by this method.

During brazing, the panel does its own programming. Sensing devices inside the honeycomb send out detailed timing and temperature information that is scanned by fully automatic programming controllers. The controllers vary input to different banks of lamps, keeping different areas of the panel at the same temperature and eliminating stresses.

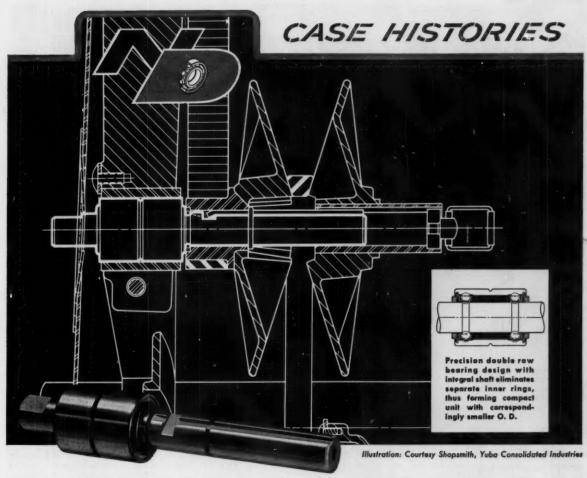
Northrop engineers have worked on the new technique, called Nortobraze, for about three years. Biggest machine they've built so far handles panels that measure 2 ft by 3 ft, but machines able to handle 12-ft long panels are considered feasible. Present machines can braze at 1700 F and heat up to 2300 F without harming panel materials. Units are so sensitive that slight drafts on a panel held at 500 F will cause instant temperature readjustment.

Further development, now being sponsored by the Air Force, is specifically aimed at adapting the brazing process to the manufacture of advanced aircraft and space vehicles. Although developed for stainless steel, the method applies equally well to titanium alloys and the exotic metals like columbium and molybdenum.



Automatic programmers scan timetemperature plots to accurately control temperature (above). Wedges (below) and other panel shapes can be uniformly brazed even though thickness varies. Core of wedge pictured tapers from 3 to 0.5 in., panel size is 22 by 34 in. Flatness exceeds AF specs.





Bearing Solves Home Power Tool Speed Changing Problem!

CUSTOMER PROBLEM:

Require low cost, compact idler shaft assembly for speed changer in popular, multi-purpose home power tool. The assembly must mount on ball bearings . . . operate at speeds up to 6000 RPM.

SOLUTION:

N/D Sales Engineer, cooperating with customer engineers, recommended a single N/D ball bearing —a compact integral shaft unit designed as part of idler assembly. The unit permits one of two interlocking variable pitch pulley halves to slide axially on shaft when changing pitch at high speed. This precision, automotive type fan and

water pump bearing eliminates extra parts inventory and shaft machining . . . reduces assembly time. In addition to solving complex design problem, N/D's compact heavy-duty ball bearing is integrally sealed for protection against sawgenerated dust . . and lubricated-for-life for added end user sales appeal!

If you're designing new equipment, why not call your New Departure Sales Engineer. He probably can help engineer your application with a standard, volume-produced N/D ball bearing that will help solve your bearing problem. For more information contact New Departure Division, General Motors Corporation, Bristol, Connecticut.

Replacement ball bearings available through United Motors System and its Authorized Bearing Distributors.



NEW DEPARTURE

BALL BEARINGS

proved reliability you can build around

Fine Arts in the Foundry

Artists May Rebel, But Industry Weighs MIT Foam-Vaporization Casting Process





Carved with a grapefruit knife and finished with a file, the foamed polystyrene pattern for the 400-lb Pegasus (left) vanished completely when molten bronze was poured into the sand mold. Perfection of the foam-vaporization process at MIT's Foundry Metallurgy Dept. promises to revive the

dying art of art casting in the U. S. Soon to be cast is a 9-ft bronze "Crucifix" (right); minor pieces have been done in ductile iron. Simple and flexible, the new casting technique can be fitted into existing foundry facilities, may offer cost-cutting possibilities to fabricators of more mundane objects.

CAMBRIDGE, MASS.—A polystyrene Pegasus—springing not from Medusa, but from an MIT foundry—is the cellular first step in an art-casting innovation, possibly the first in 5000 years for the ancient craft.

Alfred M. Duca, professional artist and research associate at MIT's Department of Metallurgy, has perfected a "foam-vaporization" process so simple and cheap that it promises to revolutionize the casting of large and intricate art objects. Besides restoring heroic statuary to public parks, the new technique may find application in not-so-fine-art foundry jobs.

In the new technique, patterns for statuary like Pegasus are carved by Duca from blocks of foamed polystyrene with simple knives and files. Because the plastic is easy to work with and is exceedingly light (1.8 to 6 lb per cu ft), the designer is offered unusual design freedom, needs no structural supports on his model for rigidity.

Borrowing a technique from industrial foundrymen, Duca reinforces his mold by "freezing" sodium silicate (mixed in with the sand) by pumping through carbon dioxide. Molten metal (400 lb of bronze for Pegasus), when poured into the mold's inlet vents, vaporizes the plastic completely, giving an exact replica of the carved pattern.

Duca, a prominent Boston artist, works at MIT with the co-operation and support of Professor Howard Taylor, holder of the country's first endowed chair in foundry metallurgy. Funds for the foam-vaporization project come from a Rockefeller Foundation grant. Industrial foundrymen can sympathize with problems of artists like Duca caught in the high-cost-of-labor squeeze.

Outlining his search for a solution, he says: "Because of the costs involved, art casting of sculpture has nearly disappeared from the American scene. Sculptured pieces are sent to be cast in Europe, which is expensive and time-consuming."

According to Duca, there are several modifications he wants to make in the process: Artists, for example, who generally prefer to work directly with their hands, rather than with knives and shapers, would prefer a more tactile material. For more design freedom, artist-sculptors are also looking for a wider range of surface textures than those offered by stock polystyrene.

Duca anticipates that some sculptors may, at first, reject the new artcasting technique: This because of the artist's "built-in love of passive materials such as clay and wax..."



"Caged" for Longer Life!

The two land-riding cages in Torrington Spherical Roller Bearings assure proper roller spacing and guidance, even under rugged conditions of shock load and sustained high speeds. These fully machined cast bronze cages operate independently. Their design eliminates drag on rollers. These high-strength cages help bearings give longer life by providing low friction, smooth running and cool operation. Highly effective and generous lubrication of all contact surfaces is achieved with the open-end cage design.

The result: Torrington Spherical Roller Bearings are built to give extra years of unmatched service life in heavy-duty applications. Torrington's long experience in design, engineering and manufacture of every basic type of anti-friction bearing provides the finest spherical roller bearings available. You'll find it pays to standardize on Torrington.

Superior design features of TORRINGTON SPHERICAL ROLLER BEARINGS

- integral guide flange for roller stability
- asymmetrical rollers seek flange for positive guidance
- electronically matched rollers
- size-stabilized races
- fully machined land-riding bronze cages
- controlled internal clearances
- · even load distribution
- inherent self-alignment
- · long service life

progress through precision

TORRINGTON BEARINGS

THE TORRINGTON COMPANY

South Bend 21, Indiana . Torrington, Conn.

Glider plus Engine: Convertible Soaring Machine



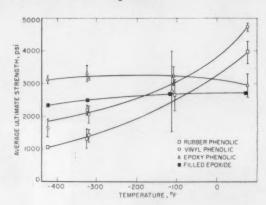


Rear-mounted engine driving a pusher propeller gives this conventional sailplane a built-in thermal. During gliding, the craft's two-bladed propeller is fully concealed by the tail assembly cross section. Cover flaps further minimize drag or, in intermediate position, serve as air brakes. Cooling flaps, open when the engine is running, are also closed

for gliding. Elevator is mounted high to avoid interference from propeller slipstream. Known as the RW-3 Multoplane, the craft started out as a pure glider, is now used extensively as a private two-place airplane. It was designed by Hans Otto Fischer of Rhein-Flugzeugbau, Krefeld-Uerdingen, Germany; has not, as yet, appeared in this country.

NBS Finds Adhesives Erratic in Supercold

Strength of adhesives tends to decrease with temperature. But epoxy phenolics are an exception: Although both rubber and vinyl phenolics are much stronger at room temperature, epoxy phenolics outperform hem over the entire low - temperature range — especially near absolute 0.



Boulder, Colo. — Best metal adhesives at room temperature aren't the best at low temperatures. National Bureau of Standards scientists recently checked out four types over a wide temperature range—down to -424 F—and found that two kinds of tensile failures occur: 1. Adhesive failure at the interface between adhesive and the metal. 2. Cohesive failure within the adhesive and the supporting cloth.

Rubber phenolics and vinyl phenolics (two of the adhesives tested) fail adhesively. At each test temperature, the resin parts from the metal in large flakes.

Epoxy phenolics fail in a predominantly cohesive manner. About 30 per cent of the cohesive failure occurs within the supporting glassfiber cloth, and the rest takes place in the rectangular spaces between strands (where the resin parted from the cloth while still adhering to the metal). Adhesive failure appeared along strands where pressure on the bond during the curing process had left a thin glue line.

Bonding of filled-epoxy samples (the fourth type of adhesive checked) proved inferior—as attested by discolored regions and pitted areas. In some cases only 70 per cent of the available area was well bonded at low temperatures. Failures were usually cohesive.

Personal Design Show Guide

Next issue of Machine Design will feature a comprehensive 32-page Show Guide, including a roundup of new products on display, a list of all exhibitors, floor plans of the Coliseum showing location of each booth, and a complete program.

AEC Bargain Basement Has Special on Uranium

Washington — Substantial stocks of nonfissionable uranium (U-238) are accumulating in AEC stockpiles, and though no figures are available, it is probable that the piles will continue to grow at a rate of 15,000 tons a year.

The government, worried by growing stocks, must decide whether to continue to stockpile for future use as an energy material, or to sell ore at an established fair price. It looks like Hobson's choice.

To appreciate the future demands for nuclear fuels, AEC experts calculated requirements for the year 1980: A liberal estimate has fast breeder reactors (the type that uses depleted uranium) using 10 per cent of total stocks available (including 22.6 tons a year of nonfissionable U-238).

If the Commission is to sell their stock, they must first develop new markets, since the total consumption of uranium by industry prior to WW-II was only about 100-tons a year. To help out, Battelle Memorial Institute has prepared a brochure (published by the AEC) under the title, "Potential Nonnuclear Uses for Depleted Uranium." Some possible new uses:

Counterweights and Ballast: As
of January, 1959, U. S. scheduled
airlines owned about 200 transport
planes; average weight of ballasts
and counterweights in each plane is

about 200 lb. Some of this is lead and some tungsten. If the price were right, it could all be replaced by uranium.

Metallurgical: Uranium additives harden steel without causing embrittlement, toughen cast iron, produce corrosion - resistant and work-hardenable alloys. However, uranium's strong tendency to combine with nonmetallic elements now makes the uranium steels less than satisfactory.

 Shielding: Because of its high density and atomic number, uranium metal is an ideal material for gamma and x-ray shielding. On a weight-for-weight basis, it is superior to lead and tungsten.

 Electronics: A review of the known properties of uranium suggests that it may be developed into a valuable semiconductor material.



Advanced Seat Design

Several hundred per cent higher g-load tolerances for crews have resulted from a startling advance in seat designs. By damping two-thirds of the shock, the seat allows booster engines of twice the thrust and half the weight to develop blast-off accelerations of 90-g without crew injury. At the SAE National Aeronautics Meeting, Maj. J. A. Macdonald of WADD explained that the increased tolerance resulted from changes in the back angle and contour of the seat. Fabricated of high strength tubing and fiber net, it is 90 per cent lighter than conventional seats. It is presently scheduled for use in project Dyna Soar.

DRAFTING TRENDS



Inspecting the "locked-in" black image of Post 208TC, Vapo Tracing Cloth, are Mort Fishman of Sabatino & Fishman, Architects, and Mike Ceglia of Bernard Sacks & Associates. Mike Conlin, sales representative of local Post dealer, Philadelphia Blueprint Company, looks on.

Philadelphia engineers save hours per tracing

Remarkable reductions in drafting time, up to 40 hours per tracing, have been achieved by Bernard Sacks & Associates, Philadelphia engineering consultants.

Specializing in heating, plumbing, ventilating, electrical and structural work, this firm receives basic floor plans from architect clients, then makes up separate detailed plans for each construction trade involved.

Bernard Sacks & Associates employs a system using Post 208TC Vapo Tracing Cloth, a positive-to-positive diazo process material. It reproduces with a dense, "locked-in" black image. The original drawing is reproduced on this intermediate product, one for each subcontractor. In most instances, film positives of standard details can be overlaid on the original drawing before the inter-

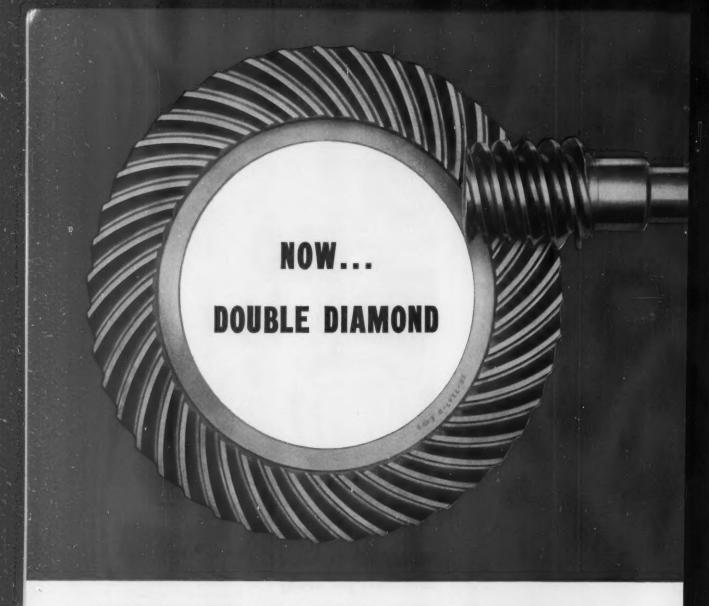
mediate is made, thus saving considerable drafting time.

Custom details or revisions are drawn directly on the 208TC intermediate, thanks to its excellent ink and pencil line receptivity. The finished plan is a combination of basic floor plan, transparent base overlays and additional drafting. It can be duplicated in quantity by any reproduction process.

Post Tracing Cloth intermediates, as in the above instance, are used in a wide variety of applications by many industries to help reduce costly board time. For more information on Post 208TC (black image) or 209TC (sepia image), and how they can help your company produce drawings and prints more economically, write to Frederick Post Company, 3652 Avondale Avenue, Chicago 18, Illinois.



SENSITIZED PAPERS & CLOTHS . TRACING & DRAWING MEDIUMS . DRAWING INSTRUMENTS & SLIDE RULES ENGINEERING EQUIPMENT & DRAFTING SUPPLIES . FIELD EQUIPMENT & DRAFTING FURNITURE



HIGH-REDUCTION BEVEL GEARS

To the nine gear types* already made by us for a long list of leading manufacturers, we now add High-Reduction Bevel Gears to meet a growing demand for the economy and speed reduction accomplished by this type of power transmission.

These DOUBLE DIAMOND High-Reduction Bevel Gears will supply speed reduction normally considered impractical in a single gear set of this type. In many cases they will replace more complex and more costly gear systems, thus improving design and achieving simplicity, while considerably lowering costs.

One of our gear engineers would be more than pleased to meet with you to discuss fully the interesting possibilities of this new member of the DOUBLE DIAMOND family.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA



GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS



*Angular bevel gears, Helical gears, Spur gears, Flywheel ring gears, Hypoid bevel gears, Straight bevel gears, Spline shafts, Zerol† bevel gears, Spiral bevel gears. Also gear assemblies.

TREG. U.S. PAT. OFF.

Circle 412 on Page 19



Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Actuators, Adv. 27 Airplanes, Edit. 22 Alloys, high temperature, Adv. 115, 184 Aluminum and alloys, Edit. 188; Adv. 9, 87, 211 Atomic energy, Edit. 23, 26, 34 Automobiles, Edit. 32, 158

Balls, Adv. 41
Batteries, Edit. 23
Bearings,
ball, Edit. 202; Adv. 11, 70, 72, 100, 203, 247, 248
roller, Adv. 13, 21, 108, 177
sleeve, Edit. 188; Adv. inside front cover, 190
Belts, transmission, Edit. 127; Adv. 53, 89
Blowers, Edit. 192
Books, Edit. 233
Brakes, Adv. 208
Brass (see Copper and alloys)
Bronze (see Copper and alloys)

Capacitors, Edit. 202
Carbon and graphite parts, Adv. 42
Castings,
die, Adv. 114, 230
investment, Adv. 192, 227
iron, Adv. 62, 191, 201
malleable iron, Adv. 84, 85, 93
meehanite, Adv. 113
nonferrous, Adv. 239
steel Adv. 62
Chain,
conveyor, Adv. 207
transmission, Adv. 37, 183
Clamps, Edit. 214
Clutches, Adv. 33, 49, 57, 71, 214
Coatings,
decorative, Adv. 223
protective, Adv. 98
Color in plastics, Edit. 120
Compressors, Adv. 246
Computers, Edit. 43, 181, 198

Connectors, electric, Edit. 188
Contactors, Adv. 198
Control systems,
mechanical, Adv. 160
pneumatic, Adv. 86
Controls,
electric, Edit. 179, 214; Adv. 101
hydraulic, Edit. 242
mechanical, Edit. 244
pneumatic, Adv. 248, 249
Converters, torque, Edit. 130
Copper and alloys, Adv. 77
Couplings, shaft, Adv. 181, 186, 226
Cylinders,
hydraulic, Edit. 191, 238; Adv. 60, 107,
219, 245
pneumatic, Edit. 191, 212; Adv. 66,
107, 245

Drafting equipment, Edit. 228, 232; Adv. 15, 95, 171, 187, 246
Drafting techniques, Edit. 137, 150
Drives, adjustable speed, Edit. 172, 201; Adv. 51, 92, 94, inside back cover
Ducts, Edit. 208

Electric equipment (see specific type)
Electronic equipment, Edit. 25, 34, 199,
207, 230; Adv. 44, 56
Engineers, Edit. 23
Engineering department (see Management
or Drafting)
Engines, Edit. 158

Fans, Adv. 83

Fasteners,
bolts, studs, screws, Adv. 173, 195, 246
nuts, Edit. 198; Adv. 249, 250
quick operating, Edit. 204; Adv. 118,
195
retaining rings, Edit. 188; Adv. 97
rivet, Edit. 190; Adv. 215, 230

Fiber, Adv. 69

Filter materials, Edit. 151
Filters, Edit. 197
Finishes (see Coatings)
Fittings, pipe, tube, and hose, Edit. 192, 204; Adv. 231
Folded fastening, Edit. 138
Forgings, Adv. 78, 235
Forming, Edit. 36

Gages (see also Instruments) pressure, Adv. 244 Gears, Adv. 16, 65 Generators, electric, Edit. 219

Heaters, Adv. 31
Honeycomb materials, Adv. 254
Hose,
metallic, Edit. 199; Adv. 5
nonmetallic, Adv. 82, 180
Hydraulic equipment (see specific type)

Instruments, Edit. 230; Adv. 192

Jacks, worm gear, Adv. 247

Lubricants, Adv. 47, 73 Lubrication, equipment, Edit. 238; Adv. 222 systems, Adv. 104

Machined parts, Adv. 176
Materials handling equipment, Edit. 154, 156
Meetings, Edit. 45
Metals (see specific type)
Motors, (electric)
fractional and integral hp. Adv. 50, 80, 106, 117, 220, 224, 233, 234
gearmotors, Adv. 76, 112, 243
Mountaings, vibration and shock, Adv. 83,

MACHINE DESIGN is indexed in the Applied Science & Technology Index and the Engineering Index, available in libraries, generally. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

Nameplates, Adv. 243 Nickel and alloys, Adv. 61

Packings, Edit. 204; Adv. 204
Planetary gear ratios, Edit. 161
Plastics, Edit. 22, 45, 191, 226; Adv. 64, 206, 212
laminates, Edit. 218; Adv. 68
molding, Adv. 228, 241
Pneumatic equipment (see specific type)
Potentiometers, Edit. 222
Power package, pneumatic, Adv. 105
Power supplies, Edit. 228, 232
Pumps,
hydraulic, Edit. 213, 219, 222; Adv. 96, 175, 178, 185, 196, 249
Pushbuttons, Adv. 74

Rectifiers, Edit. 216
Reducers, speed, Adv. 189, 193
Regulators,
pressure, Edit. 208
Relays, Adv. 24, 110, 203
Rheostats, Adv. 200
Rockets, Edit. 26
Rubber. Edit. 198, 218; Adv. 67, 204
molding, Adv. 2

Screws, power, Adv. 202
Seals, Adv. 46, 210, 218, 238
Shafts, Adv. 116
Springs, Adv. 43, 48, 217, 237
Sprockets, Adv. 37, 179
Stampings, Adv. 103, 114
Steel, Adv. 35, 54
stainless, Edit. 42
Switches, Edit. 126, 127, 129, 199, 213, 223;
Adv. 29, 90, 101, 194, 243, 250, back cover
Systems,

Systems, electromechanical, Edit. 180 hydraulic, Adv. 7 mechanical, Edit. 240 pneumatic, Edit. 30; Adv. 105, 229

Thermostats, Edit. 194; Adv. 52 Timers, Adv. 197, 216, 220, 247 Transmissions, adjustable speed, Adv. 245 Tubing, Adv. 109, 111, 234, 253

Vacuum-melted alloys, Adv. 55 Valves, hydraulic Edit. 194, 223; Adv. 79, 242 pneumatic, Adv. 1, 242 Vibration analysis, simplified, Edit. 141

Welding, Edit. 154 Wheels, Adv. 250 Wire and wire products, Adv. 240

for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 182

ITEM NUMBER		ITEM NUMBER
Bonded Lubricating Films	621	Teflon Tube Fittings 633
Custom-Built Elastomers	622	Resistors and Coil Forms 634
Centrifugal Pump	623	Miniature Gages 635
Power Supplies	624	Drafting Aids 636
Industrial Plastics	625	Hollow Aluminum Bar Stock 637
Miniature Lamps	626	Hydraulic Cylinders 638
Bearing Bronzes	627	Shaft Position Encoders 639
Electrical Motors	628	Ball Bearings 640
Thermistor Elements	629	Aluminum-Bronze Alloys 641
Plastic Products	630	Aircraft Lock Nuts 642
Valve Line	631	Tantalum Capacitors 643
Hardness Testing Data	632	Resilient-Mounted Motors 644

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 188

NUM	TEM BER		TEM
Retaining Ring	645	Tunnel Diodes	672
Electric Motor	646	Pressure Regulators	673
Midget Bearing	647	Duct Fittings	674
Microminiature Connectors	648	Induction Motor	675
Fabricated Aluminum	649	Nylon Ratchet Buckle	676
Servo Motor	650	Air Cylinder	677
Microminiature Rivets	651	Centrifugal Pumps	678
Plastic Jacketed Cables	652	Potted Limit Switches	679
Midget Cylinders	653	Plastic Cable Clamp	680
Vane-Axial Blower	654	Compact Stepping Devices	681
Steel Fitting	655	Silicon Power Rectifier	682
Solenoid Valves	656	Hydraulic Safety Lock	683
Precision Thermostat	657	Teflon-Glass Laminate	684
Hydraulic Filters	658	Sponge Rubber	685
Digital Readout	659	Double Pumps	686
Self-Locking Nut	660	Motors and Generators	687
Fluorocarbon Rubber Parts	661	Trimming Potentiometers	688
Switch Light	662	Centrifugal Pump	689
Zinc-Plated Shield	663	Hydraulic Control Valve	690
Teflon-Lined Hose	664	Pressure Switch	691
Adjustable-Speed Drives	665	Epoxy Plastic	692
Tantalum Capacitors	666	Drawing Kits	693
Pillow-Block Bearings	667	Power Supplies	694
Hydraulic Packing Material	668	Miniature Accelerometers	695
Cable-Clamp Assembly	669	General-Purpose Oscilloscope	696
Quick-Release Fastener	670	Electric Duplicator	697
Tube Fitting	671	Transistorized Power Supply	698

Apr. 28, 1960	Circle item number for information on products advertised or described or copies of literature.	SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE Page No. Title of Article
402 432 462 492 403 433 463 493 404 434 464 494 405 435 465 495 406 436 466 496 407 437 467 497 408 438 468 498 409 439 469 499	321 551 581 611 641 671 701 731 761 791 821 851 322 552 582 612 642 672 702 732 762 792 822 852 323 553 583 613 643 673 703 733 763 793 823 853 324 554 584 614 644 674 704 734 764 794 824 854 325 555 585 615 645 675 705 735 765 795 825 855 326 555 586 616 646 667 705 735 766 795 826 855 327 557 587 617 647 677 707 737 767 797 827 857 328 585 588 618 648 878	
412 442 472 502 4 413 443 473 503 3 414 424 474 675 505 4 415 445 475 505 5 416 446 476 506 5 417 447 477 507 5 418 448 478 508 5 419 449 479 509 5	331 561 591 621 651 681 711 741 771 801 831 861 332 562 592 622 652 682 712 742 772 802 832 862 333 563 593 623 683 713 743 773 803 833 863 34 564 594 624 654 684 714 744 774 804 834 864 356 595 625 655 685 715 745 775 805 835 865 365 596 626 656 685 716 745 776 805 836 865 363 566 596 626 657 687 717 747 777 807 837 867 37 567 597 627 657 687 717 747 777 80	CARB INVALIB WITHOUT COMPANY NAME — TYPE OR PRINT NAME TITLE COMPANY
1 422 452 482 512 4 1 423 453 483 513 5 1 424 454 484 514 5 1 425 455 485 515 5 1 426 456 486 516 5 1 427 457 487 517 5 1 428 458 488 518 5 1 429 459 489 519 5	41 571 601 631 661 691 721 751 781 811 841 871 42 572 602 632 662 692 722 752 782 812 842 872 43 573 603 633 663 693 723 753 783 813 843 873 445 574 604 634 664 694 724 754 784 814 844 874 45 575 605 635 665 695 725 755 785 814 844 874 46 576 606 636 666 696 726 756 786 816 846 876 47 577 607 637 667 697 727 757 787 817 847 878 48 578 608 638 668 698 728 <td>ADDRESS CITY ZONE STATE Do not use this card after June 28, 1960</td>	ADDRESS CITY ZONE STATE Do not use this card after June 28, 1960
MACHINE DESIGN Apr. 28, 1960	Circle item number for information on products advertised or described or copies of literature.	SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE Page No. Title of Article
401 431 461 491 5 402 432 462 492 5 403 433 463 493 5 404 434 464 494 5 405 435 465 495 5 406 436 466 496 5 407 437 467 497 5 408 438 468 498 5 409 439 469 499 5	21 551 581 611 641 671 701 731 761 791 821 851 22 552 582 612 642 672 702 732 762 792 822 852 23 553 583 613 643 673 703 733 763 793 823 853 24 554 584 614 644 674 704 734 744 794 824 854 25 555 585 615 645 675 705 735 765 795 825 855 26 556 586 616 646 676 706 736 766 796 826 836 27 557 587 617 647 677 707 737 767 797 827 837 28 558 588 618 648 678 708 738 768 798 828 838 29 559 589 619 649 679 709 739 769 799 829 859 30 560 590 620 650 680 710 740 770 800 830 860	
412 442 472 502 5 413 443 473 503 5 414 444 474 504 5 415 445 475 505 5 416 446 476 506 5 417 447 477 507 5 418 448 478 508 5 419 449 479 509 5 419 449 479 509 5	31 561 591 621 651 681 711 741 771 801 831 861 32 562 592 622 652 632 712 742 772 802 832 862 33 563 593 632 653 683 713 743 773 803 833 863 34 564 594 624 654 684 714 744 774 804 834 864 355 565 595 625 655 685 715 745 775 805 835 865 366 566 596 626 656 686 716 746 776 806 836 836 866 376 576 597 627 657 687 717 747 777 807 807 837 867 888 568 598 628 658 688 718 748 778 808 838 868 568 596 629 659 689 719 749 779 809 839 869 40 570 600 630 660 690 720 750 780 810 840 830	CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT NAME TITLE COMPANY
422 452 482 512 5 423 453 483 513 5 424 454 484 514 5 425 455 485 515 5 426 456 486 516 5 427 457 487 517 5 428 458 488 518 5 429 459 489 519 5	41 571 601 631 661 691 721 751 781 811 841 871 422 572 602 632 652 692 722 752 782 812 842 872 433 573 603 653 653 693 723 753 783 813 843 873 444 574 604 634 654 694 724 754 784 814 844 874 875 605 605 635 665 695 725 755 785 815 845 875 65 675 605 636 666 696 726 755 786 816 846 876 877 577 607 637 667 697 727 757 787 817 847 877 88 578 608 638 668 698 728 758 788 818 848 878 698 578 609 639 669 699 729 759 789 819 849 879 579 609 639 669 670 700 730 760 790 820 850 880	ADDRESS CITY ZONE STATE Do not use this card after June 28, 1960
MACHINE DESIGN Apr. 28, 1960	Circle item number for information on products advertised or described or copies of literature.	
401 431 461 471 5 402 432 462 472 5 403 433 463 473 5 404 434 464 474 5 405 435 465 475 5 1 405 436 466 476 5 1 407 437 467 477 5 1 408 438 468 478 5 1 409 439 469 479 5	21 551 581 611 641 671 701 731 761 791 821 851 22 552 582 612 642 672 702 732 762 792 822 852 23 553 583 613 643 673 703 733 763 793 823 853 24 554 584 614 644 674 704 734 764 794 824 854 25 555 585 615 645 675 705 735 765 795 825 855 26 556 586 616 646 676 706 736 766 796 826 856 27 557 587 517 647 677 777 777 767 797 827 827 857 28 558 588 618 648 678 708 738 768 798 828 858 29 559 589 619 649 679 709 739 769 799 829 859 30 560 590 620 650 680 710 740 770 800 830 860	
411 441 471 501 5 412 442 472 502 5 413 443 473 503 5 414 444 474 504 5 415 445 475 505 5 416 446 476 506 5 417 447 477 507 5 418 448 478 508 5 419 449 479 509 5	31 561 591 621 651 681 711 741 771 801 831 861 322 562 592 622 652 682 712 742 772 802 832 862 333 563 593 623 653 683 713 743 773 803 833 863 344 564 594 624 634 644 714 744 774 804 834 864 35 565 595 625 655 685 715 745 775 805 835 865 365 565 595 626 636 686 716 746 776 806 836 866 377 567 597 627 657 687 717 747 777 807 837 867 868 868 388 568 598 628 658 688 718 748 778 808 838 868 868 39 569 599 629 659 689 719 749 779 809 839 869 40 570 600 630 660 690 720 750 780 810 840 870 840 870 840 870 840 870 840 870 840 870 840 870 840 870 870 870 870 870 870 870 870 870 87	CARS INVALID WITHOUT COMPANY NAME — TYPE OR PRINT NAME TITLE COMPANY
421 451 481 511 5 422 452 482 512 5 423 453 483 513 5 424 454 484 514 5 425 455 485 515 5 426 456 486 516 5 427 457 487 517 5 428 458 488 518 5	41 571 601 631 661 691 721 751 781 811 841 871 42 572 602 632 662 692 722 752 782 812 842 872 43 573 603 603 603 693 723 753 783 813 843 873 44 574 604 634 664 694 724 754 784 814 844 874 45 575 605 635 665 695 725 755 785 815 845 875 46 576 606 636 666 696 728 755 786 816 846 876 47 577 607 637 667 697 727 757 787 817 847 877 88 578 608 638 668 698 728 758 788 818 848 878 97 579 609 639 669 699 729 759 789 819 848 878	ADDRESS ZONE STATE ZONE

BUSINESS REPLY MAIL

No Postage Stamp Necessary If Mailed in the United States

-POSTAGE WILL BE PAID BY-

MACHINE DESIGN

Penton Building

Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO



BUSINESS REPLY MAIL

No Postage Stamp Necessary if Mailed in the United States

-POSTAGE WILL BE PAID BY-

MACHINE DESIGN

Penton Building

Cleveland 13, Ohio

Reader's Service Dept.

Permit No. 36 CLEVELAND, OHIO



BUSINESS REPLY MAIL

No Postage Stamp Necessary if Mailed in the United States

-POSTAGE WILL BE PAID BY-

MACHINE DESIGN

Penton Building

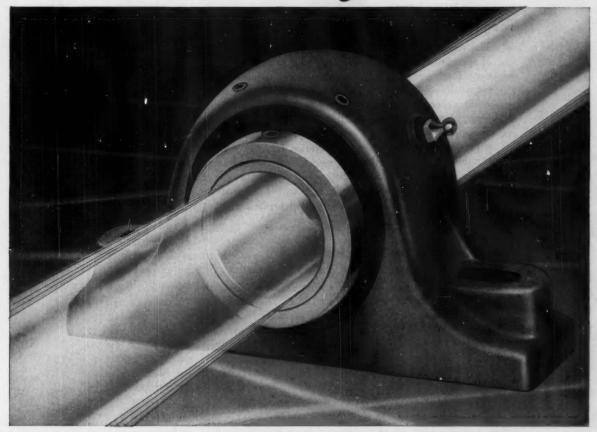
Cleveland 13, Ohio

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO



Reader's Service Dept.

Free rolling...long lasting because it's Self-Aligning



Link-Belt roller bearings compensate for misalignment of shafts and supports

Link-Belt Series 400 roller bearings have won a reputation as "the designer's choice." These self-aligning, double-row roller bearings compensate for inaccuracies in machining and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

For complete information on the Series 400—and Link-Belt's complete line of ball and roller bearings—send for our Book 2550. It's available at any one of the 40 Link-Belt offices.

Look under BEARINGS in the yellow pages of your phone book.

Also available in these mountings:







cart



hanger

LINK- BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-SELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities, Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,113



rough road ahead for the plastic car

The recent switch to plastic cabs in the truck industry has generated plenty of speculation that plastic passenger car bodies are now just around the corner. Engineers in the auto industry aren't against replacing the steel shell—eventually—but they can point to several strong reasons why plastic bodies won't appear next year, or the year after. Fabrication time is one of the biggest bogies at the present time—it requires a cycle of several minutes duration to stamp out a fender or quarter panel in plastic. This contrasts strongly with the almost instantaneous operation achieved with steel. Cost is another stumbling block. In the case of Chevrolet's Corvette (the only glass-fiber car) a relatively modest production run permits the use of low-cost dies. This pays the way for the car's plastic body. Low production rates are also a determining fact in truck cabs, coupled to an all-important weight savings.

front-office backtalk on Mach-3

Supersonic "One-up-manship" is the interesting charge aimed at U. S. aircraft builders by a top British airline engineer. The provocation: Too much "public-relations" talk about Mach-3 airliners as successors to the current jet-transport generation. Addressing the SAE National Aeronautic Meeting, B. S. Shenstone, chief engineer, British European Airways, said that materials, structures, engines—and airline pocketbooks—weren't ready for the big jump to Mach-3. Flight testing alone, he said, might require something like 20,000 flying hours and cost \$60 million. He favors the Mach 1.3 to 2.0 range, sees suitable engines and airframes as reasonable extrapolations of present state-of-the-art hardware.

ten-mile yardstick

Newest ultraprecise "yardstick" sent out free of charge by National Bureau of Standards makes use of a basic unit nearly ten miles long. That's the wavelength of a 20-kilocycle radio-frequency standard put on the air last month from the NBS Sunset Canyon Station (call letter WWVL) near Boulder, Colo. Since the ionosphere serves only as a boundary for such low-frequency waves—not as a direct reflector—the new standard is practically immune to erratic effects that plagued high-frequency broadcasts. Within its range (perhaps as far as New Zealand), the WWVL signal gives civilian and military labs accuracies which approach one part in 1010—nearly a hundred times better than possible with shorter wave broadcasts.

research problem: stop airliner bombings

What's the best way to sabotage an airplane? The Air Transport Association recently hired Stanford Research Institute to study this problem as a first step in a new program to stop destruction of airliners by passenger-carried bombs. The idea is that more specific knowledge of explosive devices might suggest ways and means of detection.

start of a stockpile

Physicists at the AEC's Savannah River facility recently invested 12 kg of plutonium to achieve a "long-term capital gain" of about a milligram of californium (element 98)—many times more than the presently available amount. The plutonium, bombarded by neutrons for two or three years, transmutes and forms 100 grams or so of curium (element 96) and some other heavy elements. The curium, bombarded by more neutrons for two or three more years, yields the californium—worth millions of dollars, but having an intangible value beyond price. The treasure will eventually be used to create larger amounts of elements like einsteinium and fermium.

on the beach: electronic engineers?

The near future may bring considerable unemployment in the electronicengineering field, warns James M. Bridge, Director of Electronics, Office of the Secretary of Defense for Research and Engineering. He points out that, during the next year, continental air-defense projects will be substantially reduced, and effort in manned-bomber electronics will also be cut back. These areas now employ 40 to 50 per cent of all electronics people working for private industry on defense programs. While new and expanding areas will take up some of the slack, many electronic specialists now engaged in defense work may find themselves without jobs, says Bridge.

metal-cutting progress: the going looks tougher

Advances in machining technology have come too easy in the past . . . in fact, the challenge has not been great enough to generate the large-scale, well-organized research attack now needed to maintain the pace. This warning comes from Cincinnati Milling's M. E. Merchant in a talk outlining trends in metal-removal. What's needed is a co-ordinated program in the "high-potential" areas, specifically, automation of machines, better tool geometry, modification of work-materials in situ, and improvements in the grinding process. According to Merchant, electrical-machining techniques (e.g., electron-beam, electro-chemical, and plasma jet), while promising, have shown no well-defined application trends, need further exploration.

isotopic batteries—low bid on waste disposal?

With amounts of radioactive waste material—and disposal problems—growing, a timely solution is at hand. The AEC has announced that a 5-watt radioisotope-powered generator will be built this year, weighing 450 lb including shielding, at a radiation level of 20,000 curies. By comparison, Pacific Ocean hot debris disposal operations from 1946 to 1959 accounted for 21,000 drums and 329 concrete boxes at a total level of 14,000 curies. The cell will operate for two years unattended, and even this limit is set by the electronic equipment which the cell powers. It is anticipated that many of these cells will find use in remote regions, or as boosters for transoceanic communication systems.



this is P&B's miniature MH relay

The MH is not a new relay.

As a matter of fact, we've been building and selling this series for seven or eight years. Its reliability and exceptional longevity have been proved in business machines, airborne computers and a host of other products.

Engineers like its fast action, its small size, its light weight. They like the wide selection of contact forms...up to 18 springs (9 per stack, DC) as well as the fact MH relays can be furnished to switch loads ranging from dry circuit to over 5 amps at 115 volts, 60 cycle resistive.

A multiple choice of terminations add to the MH's versatility. This relay, for example, can be adapted for printed circuits, furnished with taper tabs or a long list of other terminals. Get all the facts by calling your nearest P&B sales engineer today.

NAX | NAX| N

MH ENGINEERING DATA

GENERAL

Breakdown Voltage: 500 volts RMS between all elements.

Ambient Temperatures: -45° C to +85° C.(-65° C to +125° C on special order.) Shock: 30g on special order.

Vibration: 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps. on special order.

Weight: 2½ azs. max. (open relay) Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: 1/8" silver standard: Palladium or gold alloy also available

Load: Dry circuits to 5 amps @ 115V AC res.

COILS:

Resistance: 22,000 ohms max.

Power: 100 mw per movable min. to 4 watts at 25°C max.(200 mw min. to meet max. shock/vibration spec.)

Duty: DC: Continuous. AC: Intermittent (Two pole relay max.)
open. Sealed units supplied with
full wave rectifier inside can.

Voltages: DC: Up to 110 volts. AC: Up to 230 volts 60 cycles.

The relays below are variations of the MH relay structure.



MA LATCHING
Electrical latch, mechanical reset. Small, versatile and offered
with selection of contact



ME CONTACTOR

Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



MH SEAL-TEMP
Features sealed coil to minimize contact contamination.
Available as hermetically
sealed relay only.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

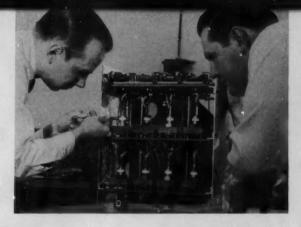


POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

DC AC Conversion

. . . the semiconductors are in solid



POWER-HANDLING capabilities of semiconductor inverters are increasing rapidly—from a few watts a couple of years ago to about 150kw this year. And the devices are demanding more attention from designers. They may eventually prove to be the best way of converting dc to ac, Westinghouse scientists report.

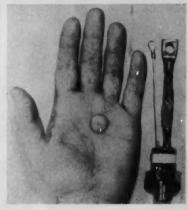
Several reliable and efficient inverters now exist: 1. Conventional motor-generator sets, 2. Mercury-arc rectifier inverters (ignitron inverters). 3. Newly developed semiconductor power inverters.

Although motor-generator sets have evolved over a period of years, they have disadvantages. They are rotating devices, so bearings, carbon brushes, and commutators must receive maintenance, and output power is not available until they reach speed. Also, since a motor-generator set has a fixed geometry, fitting elements into existing space is often difficult, if not impossible.

Ignitron inverters—basically static units—need little maintenance, opSilicon wafer (right), smaller than a dime, is the heart of the Westinghouse Trinistor. Current densities in the wafer are now as high as 500 amp per sq in., and it controls 100 amp at 200 v. But by 1965, these limits will reach 1000 amp per sq. in., and 1000 amp at 1000 v. Inverter (above) contains eight Trinistor "switches."

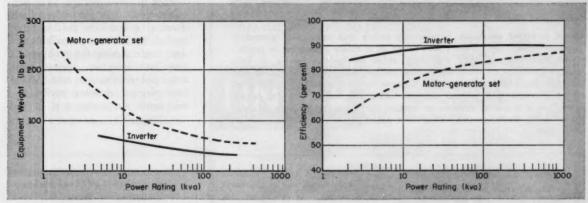
erate quietly without arcing, and are fairly efficient. They are especially suitable for special applications—such as in areas where explosive gases might be present, and where the initial high cost of the system can be tolerated.

Semiconductor inverters, though hardly out of the laboratory stage, already offer high reliability, low maintenance, and minimum noise generation. In addition, weight and volume of this new type can be much less than that of other types. Compared to the motor-generator set, the semiconductor inverter will weigh only half as much and be only half as big. Further, since it's made up of small components, it can be tailored to almost any geo-



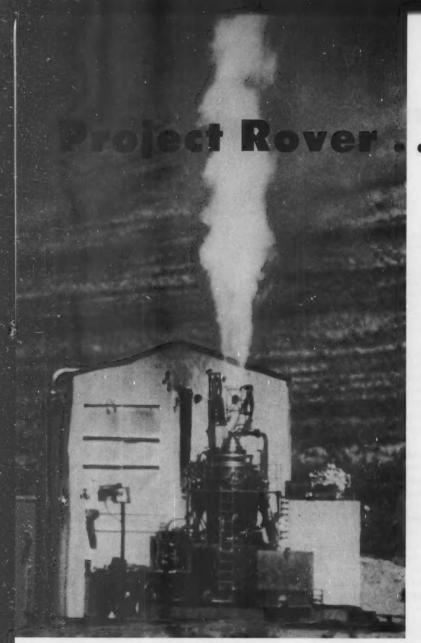
metric form.

Perhaps the most important single argument for the semiconductor unit is efficiency, said to be potentially higher than for any other type. Unlike the motor-generator set, semiconductor - inverter efficiency doesn't vary with output frequency. In the 10 to 1000-kva size range, efficiencies of 87-90 per cent are possible, compared to 75-88 per cent for motor-generator sets.



Static inverters convert dc to ac more efficiently, weigh less, and take up less space than conventional equipment. Motor-generator sets become smaller when they are designed for higher frequencies, but their operating efficiencies decrease. Efficiency of the static inverter does not depend on frequency, however, and it too can be designed smaller for high-frequency operation. Curves (above) com-

pare the two types when they are designed for 60-cycle use. At higher frequencies, advantages of static inverters are even more pronounced. Drawback at the present is price, but even this should be licked in the future. During 1959, cost came down 75 per cent, and Westinghouse spokesmen predict that by 1965 Trinistor inverters will cost less than conventional equipment.



Kiwi-A is tested nezzle-up, a relatively simple and economical procedure. Chemical rockets are normally down-fired as a safety precaution to prevent fuel-oxidizer mixtures from exploding, either on ignition failure, or from residual afterheat on shutdown with propellant leakage. In a Kiwi-A test, hydrogen gas flow is initiated prior to power runup and the hydrogen lighted off by a butane torch passed over the nozzle. No reactor shielding is provided, nor is any attempt made to contain the reactor or fission products in the exhaust. Radiation and fallout have posed no serious problems.

The nuclear rocket contender for

DURING THE NEXT DECADE, the fullback on any space-exploration team will be one of the mighty chemical boosters, Atlas, Saturn, or Nova. Their ability to plow through the gravity wall between earth and outer space is not likely to be challenged. What is needed is a fast, open-field runner for free-space propulsion. Right now the slot is up for grabs.

Candidates for space-vehicle propulsion include plasma engines, ion engines, solar sails, and the nuclear-rocket engine. Because much is already known about the performance of land-based reactors, the nuclear rocket is at least assured a fair tryout for the job. A combined effort by the Air Force and AEC, under the project designation Rover—is aimed at fitting and polishing a reactor for space.*

Design and operation of a nuclear-rocket engine is strikingly similar to a chemical system. Basic difference is the substitution of a nuclear reactor for the conventional combustion chamber. But other important differences also exist: The number of tanks, pumps, lines, and valves required in the bi-propellant chemical system are double those needed in the monopropellant nuclear engine. Also, the problems of propellant injection, mixing, ignition, and combustion which have long plagued chemical rocket development are nonexistent in the

*AEC Report: TID-8520.

Nuclear vs. Chemical

The difference between chemical and nuclear rockets—and the fundamental limitations of chemical rockets—are illustrated by this expression of specific impulse:

impulse: $I = \text{const} \times \sqrt{\frac{B}{M}}$ where (for both chemical and nuclear

rockets) specific impulse I varies directly as the square root of the energy, E, and inversely as the square root of the mean molecular weight, M, of the propellant exhaust products. Energy released by heat of combustion and molecular weight are inherent properties of the chemical propellant combination. The best high-energy chemi-

cal propellants have molecular weights in the range of 15 to 20 and maximum specific impulses of about 415.

Since energy is generated independently by the fission process in the nuclear rocket, a propellant of the lowest possible molecular weight, such as hydrogen, can be selected. For an equivalent energy release to the pro-

looks like top interplanetary flight

nuclear-propulsion system.

Since similarities in the two systems permit the direct application of chemical-rocket technology to nuclear-rocket development, primary emphasis now is on the reactor.

High specific power, or high power density (kw per lb), peak operating temperature, and fast startup (the customary slow reactor startup would be disastrous for nuclear rockets, since large amounts of propellant would be ejected at degraded temperatures) are primary reactor design objectives. Also, energy released by the fission process must be transferred to the propellant at the highest possible efficiency. Core designs in which U-235 is held in the solid, liquid, or gaseous states have all been considered. Only the solid-fuel-elementheat-exchanger reactor shows promise for early use. This limits the temperature to which the propellant can be heated-it must be below the melting point of fuel-element materials. This problem isn't serious, however, because hydrogen heated to only 400 C provides a specific impulse of 415, equal to that of advanced chemical rockets usinghydrogen-oxygen as a bi-propellant.

Fuel-element materials of current interest are the ceramics, including the refractory metal carbides, and the refractory metals, which have melting points extending to about 4000 C. It is generally believed that a specific impulse of 800, which re-

pellant in both systems, the use of hydrogen will provide a factor of three increase in specific impulse for the nuclear rocket. The energy per unit mass from fission fuel is about 107 times that available from the best chemical propellants. However, the problem still remains—how to convert that energy efficiently in a reactor.



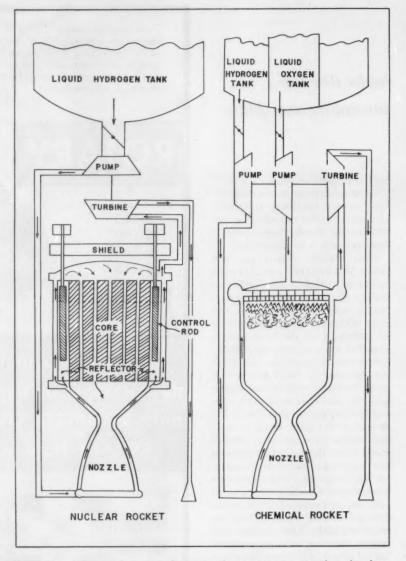
quires a temperature of about 2000 C, can be achieved in a first-generation rocket reactor.

Hydrogen's low density poses almost as great a problem as its low temperature. The volume flow rate of the oxygen pump which feeds a 150,000-lb-thrust Atlas engine is 2600 gpm. An equivalent hydrogen pump would only be adequate to cool a 400 megawatt reactor producing 20,000 lb of thrust.

Luckily, the Air Force demonstrated considerable foresight in initiating the design of Rover's fuel pump back in 1956. The pump, now completed, is an axial-flow design and the largest liquid hydrogen pump known to exist. There are still differences of opinion, reminiscent of early turbojet development, as to whether axial flow or centrifugal-flow pumps are best suited for Rover.

In comparing the over-all performance of space vehicles powered by nuclear or chemical stages, payload fraction, or ratio of payload weight to vehicle gross weight, is the primary measure of vehicle performance.

For kerosene-oxygen systems, the payload fraction vanishes for a single stage vehicle at a characteristic velocity less than 30,000 feet per second. Hence, for all missions requiring greater velocity, the vehicle designer must resort to staging. There is a practical limit beyond which small payload gains do not justify additional stages, and an ultimate limit characterized by an infinite number of stages. Payload fraction can only be improved and mission limits extended by higher specific impulse. A hydrogenoxygen ICBM, for example, could deliver twice the payload of current kerosene-oxygen missile. The payload fraction for the more difficult



Similarity between nuclear and chemical-rocket engines is pointed up by these schematics. Nuclear rocket has a reactor in place of the combustion chamber.

lunar mission would be more than tripled.

Nuclear-rocket proponents suggest that Saturn and Nova are likely candidates for the first trial of re-

*Nuclear stages

actor propulsion systems. Advantages to be gained by using nuclearpowered upper stages are summarized in the following tables prepared by the Air Force.

All Chemical Staging

Stage	Stage weight (lb)	Cumulative weight (lb)	Stage thrust (lb)	Characteristic velocity increment (ft/sec)
Payload	9000	9000		
5th	11,000	20,000	30,000	9000
4th	35,000	55,000	80,000	11,500
3rd	95,000	150,000	200,000	11,500
2nd	250,000	400,000	800,000	11,500
1st	700,000	1,100,000	1,500,000	8100

Five-stage Saturn, a plumber's nightmare, is reduced to three stages—with four times the payload capability—by the use of nuclear-rocket upper stages. Air Force spokes-

Nuclear Upper Staging

Stage	Stage weight (lb)	Cumulative weight (lb)	Stage thrust (lb)	Characteristic velocity increment (ft/sec)
Payload	36,000	36,000		
3rd*	84,000	120,000	100,000	20,500
2nd*	280,000	400,000	400,000	23,000
lst	700,000	1,100,000	1,500,000	8100

men close to the nuclear-rocket program estimate that the Saturn configuration in the table at right could be ready for blast-off within 15 years.

Whether Congress would along with giving the President this authority, however, is not certain.

nething ement 1960s." ply addiite twice

ed. continued, consumer nd invested re local and g on eduproviding itself, ache said. eleration

imilar to yield an ain what ed. "And if we suca higher atput per upply deconomy 's to take e average rould rise 3.2%. And amount to auch as the tivity were ild be even uch figures irena. Mr.

om some ninistraowth to rnment's er a rate % a year. his view, an of the vill hold e Presireport ederal

MAJOR MERGER SWITCH INDUSTRY

vance

min. tration

ing about a

1961. Dati

from about

three and a

billion and

to reducin

advane Wita

he po!

to set

"prefe

certains

duction

unemplo

entire econ

tioned, mu

the public

not resulti

Indeed!

dustry try

"Price re

rapid produ

be "normal

ductions, he

to keep the

"A nat

this crite

the price

not rule

that t

And

M Con and .

pects foreca

ly, pay hold d

vancing.

The Pr

pansions

Howev Controls Company of America policies Merges Hetherington Div. With Electrosnap Corp. to form spendi New Control Switch Division. Monogy 1

One of the precision switch industry's nessmen most complete product lines has come into to help existence with the announcement by Louis Putze, President of Controls Company of America, Schiller Park, Ill., that its subsidiary Hetherington, Inc., has been merged with Electrosnap Corporation, Chicago. The Electrosnap organization was recently merged with Controls Company of America.

"This merger is important to switch users", Mr. Putze stated, "because it combines two major manufacturers of panel switches, indicator lights and limit switches for military and industrial applications into

a single source of supply.
"Now, customers need deal with just one sales engineer instead of two. Three plant locations - Folcroft, Pa., Chicago, Ill. and El Segundo, Calif.—will provide regional engineering and manufacturing facilities to speed up delivery and service.

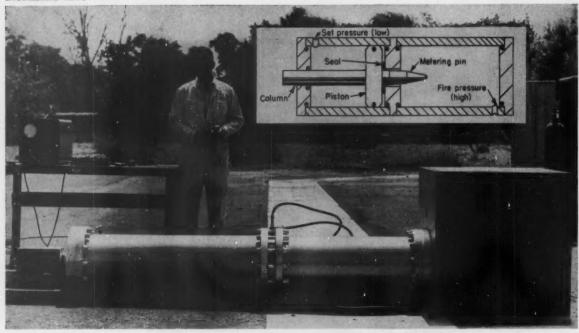
"The combination of military and industrial experience will enable the new Division to expand its activities in areas such as human factors, sub-sub-miniaturization, image displays and controls for special

"Local sales offices with factory-trained environments. personnel have been set up to provide onthe spot application engineering. An expanded nation-wide distributor organization will assure our customers of immediate delivery from local sources," Mr. Putze said.

anges in Stockholdings a large stockholders

ELECTROSNAP HETHERINGTON

CONTROLS COMPANY OF AMER 4218 W. Lake Street • Chicago 24, Illinois Telephone: VAn Buren 6-3100 • TWX No. CG-1400



Precise Pneumatic Forming Machine Doubles As High-G Impact Simulator

Nose Cones Hit the "Ocean" in Nondestructive Tests

Pomona, Calif.—Using a modified version of a versatile pneumatic forming machine, engineers are now able to reproduce the jarring impact that occurs when a missile nose cone, or any other solid object, plunges into the water at supersonic speeds. The new laboratory tool, called a Hyge machine, is based on the Dynapak metal-forming machine developed by Convair

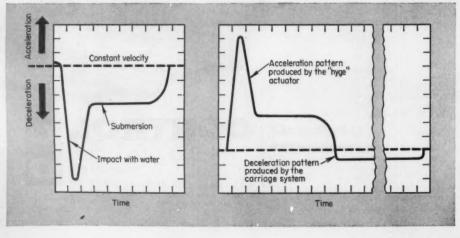
Div., General Dynamics Corp.

The technique takes advantage of the fact that g-forces are identical, regardless of whether they result from acceleration, deceleration, or centrifugal force. Past attempts at duplicating impact shocks have depended on the use of resilient or semiresilient materials against which the test object is hurled. Since the total force of deceleration has to be Cocked Hyge machine: Piston remains in position shown until "firing" pressure is reached in cylinder at right; this disengages the seal and high pressure is applied across entire face of piston, driving it to the left. Length and shape of metering pin governs flow of high-pressure air.

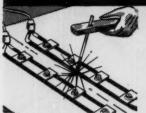
absorbed by the test facility, engineers have been limited in size and speed of the objects they can test, even if they were willing to accept the partial destruction of the facility with each test.

A Hyge water-entry simulator, by contrast, creates g-forces by an extremely high, yet controlled, acceleration. In effect, the machine creates a shock load that simulates the

Mirror image: The Hyge technique exactly reverses a water-entry event. At the end of the test, specimen is traveling at a velocity that approximates the speed of the object as it hits the water. A number of mechanical methods are used to slow the specimen down, the only requirement being that the deceleration g-forces remain low so that no additional damage occurs.



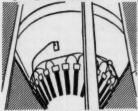
Call your CHROMALOX Man for heating answers



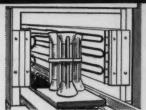
Tubular Heaters used to preheat welding plate to provide more ductile welds.



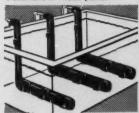
Stud Heaters for shrink fitting large studs and bolts requiring a high degree of tightne



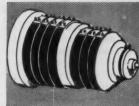
Strip Heaters clamped to hopper are thermostatically controlled to keep clay in storage at 60°F.



Far-Infrared Panels mounted in an oven for conveyor line heat treatment of metal parts.



Immersion Heaters for melting metals such as lead, solder, tin, stereotype metal and babbitt.



Strip Heater Bands for the full range of extrusion and molding temperatures.



SOLIDS? Only CHROMALOX heats so many things... so many ways

There's one best way to do any job. And you get the best results only by using that one best method.

Regardless of what your heating problems may be . . . your best chance of finding the best answer is to call your Chromalox Man.

- He represents more than 15,000 different types, sizes and ratings of electric heaters and heating elements . . . the world's largest line.
- He orders from the world's largest stock.
- And he is a heating expert . . . he understands your problem and can help you find the answer.

No matter what your heating problem is . . . solids, liquids or gases . . . call your Chromalox Man for the efficient, electrical answer. Or, check the boxes below, write your name, title, and address at the bottom of this page and mail the coupon to us.

Edwin L. Wiegand Company

7500 Thomas Boulevard, Pittsburgh 8, Pa.

- ☐ Send me Catalog 60 (General Industrial heating applications).
- Have a Chromalox Representative contact me.
- Send me specific information on the heating problems I have outlined on the sheet attached.
- ☐ Do not have a Chromalox Representative contact me.

Sales-Engineering Representatives

ALBANY, N.Y. Hobart 3-0626

ATLANTA, GA. Trinity 5-7244 BALA-CYNWYD, PA. Mohawk 4-6113 Greenwood 3-4477 BALTIMORE, MD. Hopkins 7-3280

BLOOMFIELD, N.J.

Edison 8-6900 New York: Worth 4-2990 BOSTON, MASS. Liberty 2-1941

BUFFALO, N.Y. Summer 4000 Summer 4000 CHARLOTTE, N.C. Edison 4-4244 Franklin 5-1044 CHATTANOOGA, TENN. Amherst 5-3852

CHICAGO, ILL. Harrison 7-5464 CINCINNATI, OHIO Trinity 1-0605 CLEARWATER, FLA. Phone 3-7706

CLEVELAND, OHIO Prospect 1-7112 COLUMBUS, OHIO Amherst 7-8260 DALLAS, TEX. Riverside 8-9004 DAVENPORT, IOWA Phone: 6-5233

DENVER, COLO. Glendale 5-3651 Genesee 3-0821 DES MOINES, IOWA Cherry 3-1203 DETROIT, MICH. Kenwood 8-2100 Elgin 7-0677

HOUSTON, TEX. Capitol 5-0356 INDIANAPOLIS, IND. Melrose 5-5313

KANSAS CITY, MO. Victor 2-3306 LOS ANGELES, CAL. Richmond 7-5191

MIDDLETOWN, CONN. Diamond 6-9606

MILWAUKEE, WIS. Broadway 1-3021 MINNEAPOLIS, MINN Federal 6-6631

NASHVILLE, TENN. Cypress 2-7016 NEW YORK CITY, N.Y. (See Bloomfield, N.J.)

OMAHA, NEB. Atlantic 760 PHILADELPHIA, PA. (See Bala-Cynwyd, Pa.)

PITTSBURGH, PA. Emerson 1-2900

PORTLAND, ORE. Capitol 3-4197 RICHMOND, VA. Atlantic 8-8758

ROCHESTER, N.Y. Hamilton 6-2070 ST. LOUIS, MO. Chestnut 1-2433

SAN FRANCISCO, CALIF. Underhill 1-3527

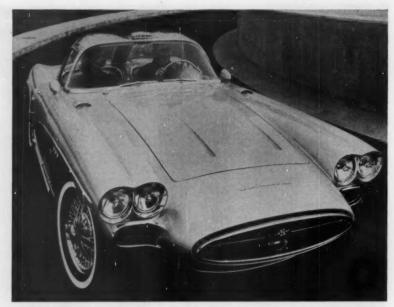
SEATTLE, WASH. Main 4-7297 SYRACUSE, N.Y. Granite 4-3933

WICHITA, KAN. Amberst 2-5547



exact environment. Its big advantage comes from a simple fact: It is much simpler to pour energy into an object, in a controlled manner, than it is to remove energy, especially when the object is in motion. And, since the test takes place during acceleration, deceleration can be stretched over a safe distance, and forces on the test rig are moderate.

Abrupt acceleration is achieved in the Hyge machine by a unique piston-cylinder arrangement activated by compressed air. The object under test is mounted on a sliding carriage located a short distance away from the piston. On firing, the lightweight piston builds up a tremendous velocity, transmitting this to the specimen on impact. The sudden energy input creates up to 5000-g acceleration in the carriage assembly. But this shock is shortlived, lasting only until the kinetic energy of the piston has been absorbed. Piston and carriage then move down the track together, accelerated by the air flowing through the Hyge orifice.



Prototype Chevy for Tomorrow?

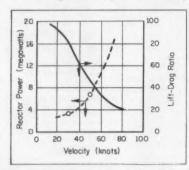
Latest of Chevrolet's experimental cars, XP-700 Corvette, incorporates the most up-to-date thinking on design and safety. Innovations include a glare-eliminating bubble top, new ideas in cockpit-air circulation, a periscope rear-view mirror that provides a completely unobstructed view of the road behind, brake-cooling air scoops, and a "floating" grille guard. The experimental Corvette will be shown at the International Auto Show in New York.

Nuclear Blimp May Watch and Wait

Chemical or Nuclear Heat Would Drive Turboprop Engines

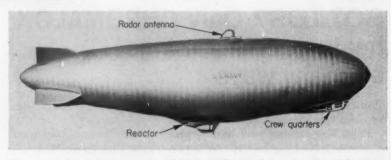
New York—Long term station keeping may be the task of a proposed lighter-than-air nuclear aircraft.

With space enough for bowling



Curves show how increasing speed cuts the lift-drag ratio, with a corresponding rise in power requirement. The 7-megawatt reactor would power most of the mission at cruising speeds of 30 to 50 knots; augmentation with chemical fuel would occur for full-power dash and for take-off and landing.

alleys for the crews, and length enough to put a football field between reactor and crew compart-



Mating of old and new may provide the "lift" needed to get the nuclear airplane program off the ground. This artist's conception shows the probable locations of reactor and crew compartments in a nuclear airship.

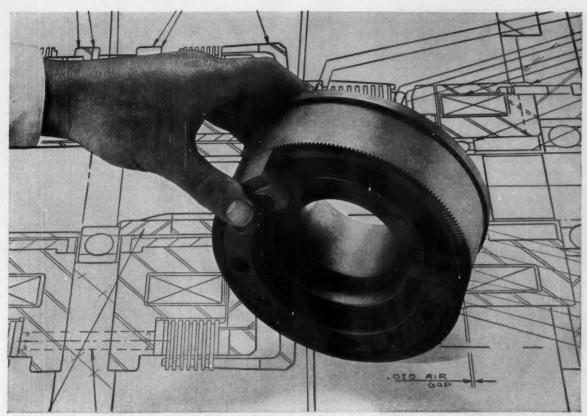
ments, the new vehicle requires a mere seven megawatts of nuclear power.

Since the biggest drawback to nuclear aircraft is the heavyweight reactor shielding, the following assets are strong arguments for the nuclear airship:

- Low reactor power, resulting from low cruising speeds and minimal take-off requirements
- Large separation between reactor and crew
- Weight-saving "shadow shielding"

Simple ground - handling techniques, stemming from ability to operate on auxiliary nonnuclear fuels.

Goodyear's Leo Jurich, speaking before the SAE National Aeronautic Meeting, presented a convincing case for the nuclear airship's chief military assignment, "watch and wait," presently performed by more expensive, less efficient methods in our defense system. He recommended the retention of Brayton-cycle turboprops, which permit the same engine to be used with both nuclear and chemical heat sources.



Bendix Elmag Tooth Clutch EZE 1200 (1200 ft.-lbs. capacity) weighs only 20 lbs. Background shows disc clutch drawing.

Bendix Electromagnetic Clutches Help You Design for Better Machine Performance

Bendix Elmag* Clutches—both Tooth and Multiple Disc types—give real help to the machine designer who wants to provide a performance "plus." These electromagnetic clutches will help your machines to outperform competitive makes . . . build your company's business by winning new customers. They have many advantages over mechanical clutches:

ELMAG CLUTCHES ARE FASTER—Engage and disengage faster; accelerate more smoothly under loads; permit faster machine operation, higher cyclic rates. CLEAN, SPACE-SAVING DESIGN—Elmag clutch units require less space than mechanical units of the same capacity. And they need no mechanical linkage. EASE OF CONTROL—Clutching control is accomplished remotely by a set of electrical contacts.

PREG. U.S. PAT. OFF.

NEW ELMAG TOOTH CLUTCH-for positive, high torque transmission Absolutely no idle torque • Engagement at relative speed possible • Disengagement possible under full load while running at maximum RPM . Bolt-on design (simple mounting adapter) • Wet or dry applications • Available from stock in torque capacities of 40 to 4,000 ft.-lbs.

ELMAG MULTIPLE DISC CLUTCH—Provides precise control and quick response in high-frequency operations. Ideal for step-by-step control of large masses. Disc stack is magnetically isolated.

ELMAG CLUTCHES ARE A RECENT BENDIX ACQUISITION FROM McCAULEY INDUSTRIAL CORPORATION

For full details, write:

Bendix-Elmira



Footsoldier Becomes ICBM Tracker With Portable Superdetector

Signal Corps Maser Claimed Most Sensitive Lightweight Yet

Washington, D. C. — Faint radio waves from distant stars or satellites can now be picked up and amplified without distortion or background noise by a new "portable ear." Described as pound-for-pound the most sensitive listening device ever conceived, the ear weighs 25 lb and can be housed in a cabinet the size of a TV console. It's now being tested by the Signal Corps.

Developed by Hughes Aircraft Co., Culver City, Calif., the superdetector may someday provide footsoldiers with the means of communicating with space vehicles. If it tests out as well as expected, the range of many Army electronic systems will be extended by tenfold. Used as an amplifier for radar and radio, the device would provide enough sensitivity to:

• Greatly extend tracking and communications ranges.

 Enable defense systems to detect ICBMs far earlier than they now can.

 Pick up signals from stars for use in radio astronomy.

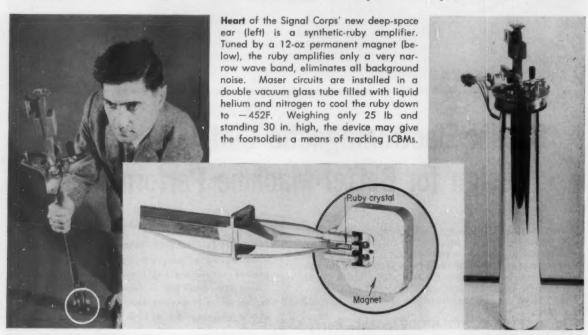
• Facilitate communications between space vehicles.

Called a ruby maser, the detector gets its name from a two-carat synthetic ruby. Mounted in a magnetic field and cooled to -452 F, the ruby amplifies a very narrow band of radio waves in the microwave spec-

trum; tuned frequency depends on magnetic field strength and orientation of the field and the ruby.

Other amplifiers—vacuum tubes and transistors—suffer from noise caused by fluctuations in electron flow. When the input signal is weak, noise can obscure the amplified signal. But the ruby doesn't depend on electron flow; its sensitivity is based on paramagnetic properties of the ultracold gem, and it generates no noise.

While masers (microwave amplifiers that stimulate emission of radiation) have been around for some time now—the principle was uncovered in 1955 — solid-state masers have previously all required huge magnets. The new Hughes maser is the first small-sized device of this type. It is expected to be the forerunner of a new family of light, small, portable masers.



Superheat Reactors May Edge Power Costs Down

SAN JOSE, CALIF.—Superheat reactors will give nuclear-power costs more punch in the fight to compete with conventional generators.

In a paper presented at the Sixth Nuclear Congress, GE's E. L. Zebroski, K. M. Horst, and P. G. Aline claimed fuel-cycle costs, together with probable capital savings for larger units, point to an over-all reduction of about 10 per cent (or 2/3 mil/kw-hr) in nuclear power costs.

They added, however, that before potential savings can be firmed up, considerable operating experience must be obtained on fuel lifetimes and the effects of fuel-element failure.

In a superheat system, saturated

steam produced by a water-type reactor is passed to a steam-cooled reactor which boosts the steam temperature several hundred degrees. The authors stated that there is no apparent incentive for raising steam temperatures above 1000 F. The higher reactor exit temperatures cause hot-spot problems which are overcome only by lowering specific power of the reactor, and hence increasing fuel rental and heater size.



How tool steel users save 5 ways with precision ground flats of GRAPH-MO®

Now you can have all the advantages of high-quality graphitic tool steel in a new, convenient form. Specify Graph-Mo® in precision ground flats and save because:

- 1. GRAPH-MO OUTWEARS ordinary tool steels 3 to 1 because of free graphite particles and diamond hard carbides in its structure.
- SEMI-FINISHED precision ground flats save you time and money by eliminating some preliminary operations.
- 3. 33% EASIER MACHINING saves you still more when you specify Graph-Mo.
- 4. GRAPH-MO'S HEAT TREATING response is

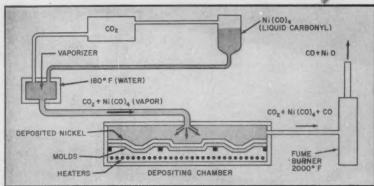
uniform, eliminates distortion in preparation.

 SPECIAL PROTECTIVE WRAPPING assures top condition when you get ready to use your Graph-Mo precision ground flats.

There is only one Graph-Mo and the Timken Company makes it. Graph-Mo precision ground flats are available in 250 different sizes to give you maximum savings. Get your stock list from your local Timken steel distributor or write direct to: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN GRAPHITIC STEELS ARE CARRIED IN STOCK BY 9 DISTRIBUTORS WITH 47 WAREHOUSES IN 39 CITIES IN THE UNITED STATES AND CANADA

All-Nickel Forming Dies Made Without Machining





CONSHOHOCKEN, PA.—A method of making pure nickel molds, tools, dies, patterns—or almost any complex shape—is possible by a new molding process that completely eliminates machining.

Developed by Budd Co.'s Carbonyl Metal Products, the new technique not only cuts time and costs, but claims a number of significant metalworking advantages. The finished carbonyl-nickel product has about five times the resistance to sand abrasion as cast iron, for example, and is superior to aluminum, bronze, and chrome-vanadium steel in this important property. It has an extremely smooth surface, and, in forming die applications, will not "cold weld" or otherwise score sheet metal being worked. The material also has high thermal shock properties (up to 1600 F) which permits rapid cooling or quenching -a trait not shared by cast-iron or

Flow diagram of the carbonyl process: Co₂ serves as the "driver," nickel-carbonyl liquid to flow into vaporizer, then, as gas, into the depositing chamber where pure nickel shells are formed. Steps in creating the shell from original master (die, mold, or pattern) are shown, right: Master in wood, plastic, or metal, 1, is sprayed with eutectic compound, 2, until a 1/2in. thick "negative" is formed. Negative is placed in sealed depositing chamber where original nickel in the nickel-carbonyl gas is deposited molecularly on the heated surface of the molds, 3. Nickel "positive" may be filled with epoxy resin, 4.

steel molds.

Applications of the Budd Carbonyl Metal Process in terms of end products are said to be virtually limitless. Biggest single application at the present time is in the automotive field where it is used in casting fuel-pump bodies, torque con3

verter and transmission housings, cylinder heads, exhaust manifolds, and brake drums. Nickel molds for complete engine-block castings in aluminum are also feasible with the new process, according to Budd.

Spokesmen for Budd say that the process will not be licensed.

AEC Rounds Up Latest Isotope Applications

Washington — Radioisotopes, the dangerous and useful byproducts of atomic fission, are rapidly becoming one of the industry's most useful tools. Latest advances in the art are surveyed in a new report from the AEC titled "Radioisotopes in Science and Industry." Dr. Willard F. Libby, in the foreword, described radioisotope applications as "promising to be inexhaustible in their benefits to mankind." Among new applications outlined were:

• Isotope Strain Gages: Use of a radioactive transducer, completely independent of physical connections to receiving elements, will solve problems of measuring strains in rotating machinery and within heavy structures.

• Impurity Tracers: By including radioactive materials in furnace liners and other nonmetallic materials in contact with molten steel during processing, metallurgists can trace sources of steel impurities. Oxygen content is one item marked out for special treatment, with oxygen contents of 5 parts per million traceable.

• Automatic Product Dating: Methods for determining the age of a material or product are mentioned

in the report. This promises to become of utmost importance to dateconscious industry. Trace quantities of radioactive materials in such diverse items as aircraft tires, pressure vessels, electronic circuits and seeds, give a quick check on their ages. All such items have a timedependent life factor, and isotope dating permits more efficient use and timely removal of perishable products from service.

Other isotope applications cited were in the fields of science, engineering, agriculture, medicine, and business. They covered such uses as measurement of corrosion in steam boilers, catalytic irradiation (Please turn to Page 41)

You can solve many problems better and at lower cost

DIAMOND

ROLLER CHAINS and SPROCKETS

You get ALL THESE DESIGN ADVANTAGES

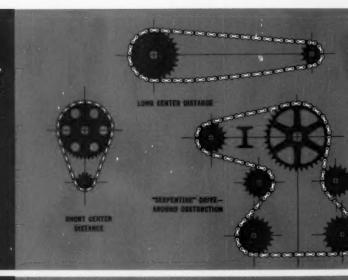
when you use



You get more for your dollar with DIAMOND Roller Chain than with any other mechanical power transmission medium. Its important design advantages (some of which are described on these pages)... plus low first cost, low installation cost and low service cost... make DIAMOND Roller Chain a highly efficient and economical solution to virtually any mechanical power transmission problem.

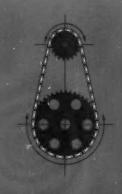
Adaptability

DIAMOND offers maximum adjustability to long or short center distances. Several shafts may be engaged, rotated in either direction at various speeds all front a common drive shaft. Speed ratio changes are made easily by changing sprockets.



Positive Power

Multiple engagement of sprocket teeth with roller links assure a non-slipping drive. Heavy static and radial loads, thrusts or bearing pressures are reduced (due to elimination of high operating tension as with belts or separating forces as with gears). DIAMOND standard roller chains cover a wide range of horsepower and speed combinations (see Table).



POSITIVE ENGAGEMENT DETWEE ROLLER LINKS AND MANY SPROCKET TEETH SPEED AND HORSEPOWER CAPACITIES FO DIAMOND SINGLE AND MULTIPLE STRANG

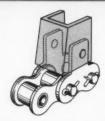
MOLLEN OIDMING		
Chain Pitch	Horsepower Up to	At Speeds As High As
14"	25	8000 R.P.M.
%"	120	4500 R.P.M.
1/2"	220	3370 R.P.M.
%"	375	2400 R.P.M.
%"	480	1800 R.P.M.
1"	950	1160 R.P.M.
1%"	1440	800 R.P.M.
11/2"	1200	650 R.P.M.
1%"	1540	475 R.P.M.
2"	2300	400 R.P.M.
21/2"	2800	280 R.P.M.
BURNELL IN		

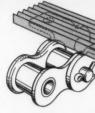
For Ratings not shown in table, write to DIAMOND Chain Company



STANDARD ATTACHMENTS AVAILABLE WITH DIAMOND ROLLER CHAIN

Various types of link plate attachments and extended pins permit the ready adaptation of DIAMOND Roller Chain to a wide range of conveying, timing or synchronized movement problems.





LITHO, IN U.S.A.

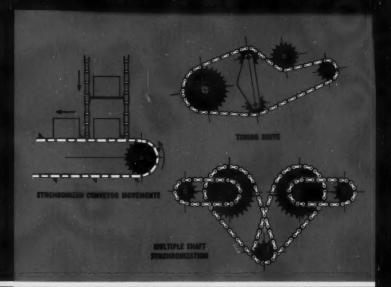
COPYRIGHT, 1999, DIAMOND C

Accuracy

Component parts of Diamond Roller Chain are manufactured with uniformity and precision resulting in close total-length chain tolerances. This means that Diamond not only operates smoothly and quietly . . . but that two or more chains may be run in parallel or to synchronize multiple shaft movements in one machine.

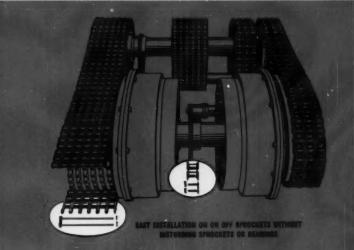
es

e-



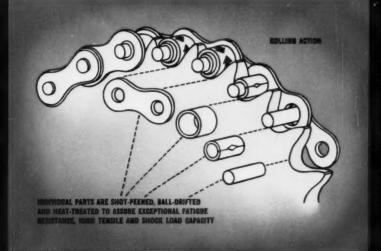
Convenience

DIAMOND Roller Chain is easily installed. It may be quickly connected or disconnected by means of a connecting link without disturbing sprockets or bearings. Installation does not require precision alignment of sprockets or shafts.

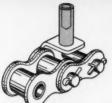


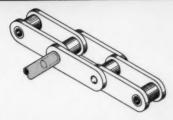
Durability

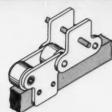
Manufacturing refinements and strict quality control are responsible for Diamond's long life and superior performance. Inherent design—positive engagement, large joint bearing areas, wide distribution of load—makes roller chain 98%-99% efficient, the highest rating of all mechanized power transmission media.

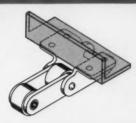














DIAMOND . . . Specialists in Roller Chain Design and Manufacture for more than 68 Years

The quality of DIAMOND Roller Chain . . . both in design and in workmanship . . . is the result of more than 68 years of specialization in solving difficult problems of load, shock, fatigue and abrasion. During this time DIAMOND has contributed many "firsts" to the capabilities of roller chain. It is the only roller chain embodying so many engineering and manufacturing refinements.



FIRST TO PRE-LOAD PRODUC-TION ROLLER CHAIN-Preloading seats pins, bushings and linkplates; takes out initial stretch.



FIRST TO STUDY FATIGUE— First to make design changes in roller chain parts for improved fatigue resistance.



FIRST TO BALL DRIFT—Pitch holes in DIAMOND chain sideplates are ball drifted for greater fatigue resistance.

(DIAMOND patent)



FIRST TO EMPLOY SEAM RE-LIEF BUSHINGS—Seam relief bushings reduce runin time and provide better lubrication.

(DIAMOND original patent)



FIRST TO PROPERLY PLACE
BUSHINGS — DIAMOND
bushing seams are placed
away from load-bearing
area for improved resistance to wear and fatigue.



FIRST TO SHOT PEEN— DIAMOND chain parts ... rollers, bushings, linkplates and pins . . . are shot peened for greater fatigue resistance.

Diamond Chain Company Representatives

ATLANTA, GEORGIA 02 FOURTEENTH STREET, N.E.

BATTLE CREEK, MICHIGAN

BOSTON, MASSACHUSETTS 845 GREAT PLAIM AVENUE, ROOM 14 D.O. 60X 247, HEEDHAM 92, MASS.

CHICAGO, ILLINOIS 212 SOUTH MARION STREET, OAK PARK, ILL

CINCINNATI 37, OHIO

CLEVELAND, OHIO

DALLAS 5, TEXAS

HOUSTON 25, TEXAS

LOS ANGELES 21, CALIFORNIA

MINNEAPOLIS, MINNESOTA 215 SIXTH STREET, S.E. NEW YORK 13, NEW YORK 78 WARICK STREET

PHILADELPHIA, PENNSYLVANIA
401 SUBURBAN SQUARE BUILDING, ARDMORE, PENN.

SAN FRANCISCO, CALIFORNIA 505 SANTA CRUZ AVENUE, MENLO PARK, CALIF.

SYRACUSE, NEW YORK
10 HOMER STREET, UNION SPRINGS, R. Y.

TULSA 14, OKLAHOMA 2230 TERWILLEGER BOULEVARD

Write for DIAMOND Ready-Reference Catalogs Covering All Roller Chain and Sprocket Needs

These DIAMOND catalogs give full description of the subjects listed, including rating, dimension, conversion tables. Also horsepower ratings, service factors and other engineering data to help you select the right chains and sprockets for your equipment.



STOCK ROLLER SHAIN AND SPROCKET CATALOG



ENGINEERING DATA BOOK FOR DIAMONI ROLLER CHAINS AND SPROCKETS

For complete information or design assistance write direct to:

Diamond Chain Company, Inc.

A Subsidiary of American Steel Foundries

402 KENTUCKY AVENUE INDIANAPOLIS 7, INDIANA

Offices and Distributors in all Principal Cities

DIAMOND

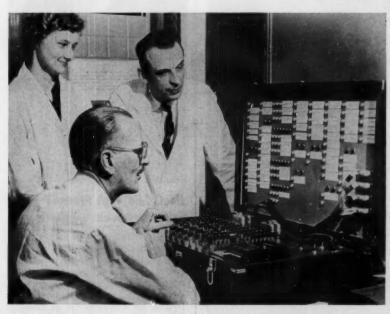


ROLLER

formation of new plastics, reduction of static electrical charges, and measurement of extreme heat.

In the words of Dr. Libby, . . . with full recognition of the present contribution of the atom to

our welfare and economy, the stage has merely been set for an era of applied nuclear sciences in which the stellar role will be played by the versatile radioisotopes.'



Bell Volunteers Design MD Training Aid

Engineers—often condemned for ignoring man's nonmaterial problems—can take heart in the accomplishments of SAVE (Service Activities of Volunteer Engineers). Organized at Illinois Bell Telephone Co., the task force is lending its special talents to hard-pressed cancer researchers. Working in their spare time, members have developed a "cyto diagnostic test apparatus" to help train cancer diagnosticians. Built around equipment from Switchcraft Co., Chicago, the device allows a student to record his diagnosis of a cancer specimen by pushing a series of buttons. Pushing another button indicates his score, and the process may be repeated until correct diagnoses are obtained.

Orbital X-15 Proposed To Cut Man-In-Space Costs

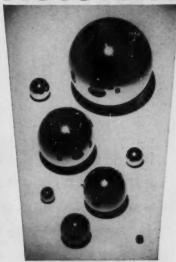
New York-Use of the rocket-powered X-15 as a reliable, economic means of putting man into an orbit -and for other manned space missions-has been proposed by scientists at Reaction Motors Div., Thiokol Chemical Corp. For the orbital assignment, the thrust of the experimental craft's liquid-fueled engine would be increased, and the vehicle would be launched from the ground by a powerful booster.

According to Thiokol spokesmen, the present X-15, now undergoing flight tests, could be modified for orbital capability with the addition of auxiliary droppable fuel tanks and a more energetic propellant.

Major advantages of modifying the X-15's powerplant for manned space missions were summed up as follows: The engine is throttleable, can be stopped and restarted at pilot discretion, and offers a wide range of performance capabilities. It can accommodate numerous propellant combinations, including the exotic fluorines and borons now under development. Propellant substitutions can be accomplished without compromising controllability, reliability, and manned safety rating.

The X-15's current XLR-99 engine (50,000 lb thrust) was developed and built by Reaction Motors.

HARD **SMOOTH** AND ACCURATE



BALLS TUNGSTEN CARBIDE

ITI tungsten carbide balls offer the greatest obtainable resistance to wear, abrasion and deformation. They retain these advantages in many corrosive environments, Other qualities include -

EXTREME HARDNESS: 89-91 Rockwell A. EXTRA-SMOOTH FINISH: 1 microinch r.m.s. or better.

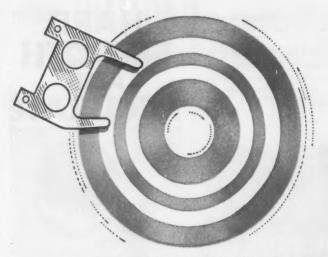
HIGH PRECISION: ±.0001" on size and .000020" sphericity are standard. Furnished to .000010" on size and sphericity

These balls are available in ALL SIZES, standard and special, from .005" to 5". Sizes from 1/4" to 1" are in stock.

> Write for quotation and specifications.



41



METAL GRAPHITE CONTACTS

AND RADIO INTERFERENCE

Since shielding and filters to reduce radio noise caused by sliding contacts are often cumbersome and always costly, it is essential that contact materials be used which, in themselves, create the least radio noise interference.

Stackpole Laboratory tests backed by extensive field experience indicate that Stackpole silver graphite operating against silver rings give satisfactory results on most sliding contact applications calling for low radio noise levels. Good radio interference reduction results are likewise obtained with Stackpole electrographite grade L31 contacts operating against electrographitic rings, as well as against silver and gold rings.

In addition to reducing radio noise interference, sliding contacts must also be able to operate at high altitudes under high pressure conditions in dry, inert atmospheres, with excess moisture, and with oil vapor. All of these ambients have come within Stackpole experience with the resulting development of materials which work well under such conditions.

Give us the contact radio noise reduction problem and the chances are excellent that Stackpole can recommend materials or testing procedures to solve it,

STACKPOLE CARBON COMPANY, St. Marys, Pa.

BRUSHES • CONTACTS • VOLTAGE REGULATOR DISCS CATHODIC PROTECTION ANODES • SEAL RINGS • CLUTCH RINGS • FRICTION SEGMENTS • CHEMICAL ANODES POROUS CARBON and dozens of other related products.



STACKPOLE

custom-engineered
CONTACTS/BRUSHES



Heat, Cold, High Pressure Form Hypersonic Nozzle

Three precisely shaped nickel shells will be used to blast air into industry's first Mach-10 wind tunnel at Douglas Aircraft Co. Manufacture of the highly critical parts required prior forming of 4-ton aluminum hand forging. This forging, by Aluminum Co. of America, was worked in an 8000 ton hydraulic press, and finish-machined to diameters of 24 in. at one end, and 3 in. at the other. After working tolerances of 0.001 in, had been met at 1440 stations on its 12-ft length, the huge mandrel was electroplated with 5/8 in. of nickel. Finally, to remove the nickel shell, the piece was subjected to subzero temperatures.

Stainless Steel Dons Coats of Many Colors

PITTSBURGH — A splash of color enters the steel mills as makers perfect a method for coating stainless steel. They have eleven colors already available to start the flow.

First uses are for automobile trim, and appliances; looking further ahead it appears possible that future submarine hulls will be black stainless, and future liquid-oxygen tanks blue stainless.

The color is achieved through the application of a chromate-base coating similar to that used on the inner lining of metal containers, Allegheny Ludlum Steel Corp., the developers, announced. The coating

may be applied by painting, rolling, or spraying, and curing takes place at a temperature of 350 F.

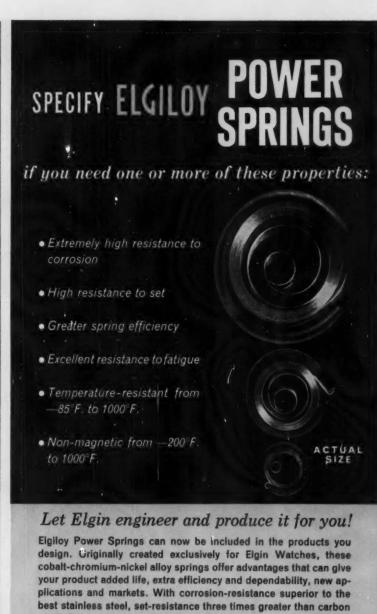
The coating process is simpler, more economical, and more effective than previous methods of making black or gray coated stainless steel, since it requires no primer, pretreating or high temperature curing. Different colors are obtained through the addition of pigments to the basic coating material.

Other advantages of the coating are cited as: Greater uniformity of color, good surface adherence, abrasion and corrosion resistance. It compares favorably with anodizing, vinyl and enameling finishes.

Standard-Size Modules Clue to Smaller Computer

Tiny modules, made in a standard size, will be mass produced to reduce computers to one-fifth of their present volume. The dice sized modules contain resistors, transistors, and diodes which, until recently, have been attached separately to printed-circuit boards. Although the idea of modules is not new, "cards" presently in use have 8 to 10 modules on them, whereas the newest development allows up to 44 or 50. Furthermore, these units, being made in standard size, can be stacked together without wasting space, and the encapsulating material is a heatconductor, which prevents circuit overheating. Republic Aviation Corp., Mineola, N. Y., who developed the system jointly with the Army Signal Corps, will use the modules to produce a two cubic foot computer (including memory drum) for use in the Army's 'Swallow' reconnaissance drone.





Elgiloy Power Springs can now be included in the products you design. Originally created exclusively for Elgin Watches, these cobalt-chromium-nickel alloy springs offer advantages that can give your product added life, extra efficiency and dependability, new applications and markets. With corrosion-resistance superior to the best stainless steel, set-resistance three times greater than carbon steel, fatigue resistance nearly twice that of carbon steel, these springs provide up to 1000% greater useful life. Elgiloy can be stamped, blanked, coiled, formed, welded, brazed, soldered, will maintain spring characteristics up to 1000°F and is non-magnetic. Consult us for full details today. We'll be glad to engineer and produce springs and other components you need in quantity.

Send for New Booklet

giving full technical details on Elgiloy. Get this informative literature—convince yourself that Elgiloy Power Springs can be a valuable addition to your product!

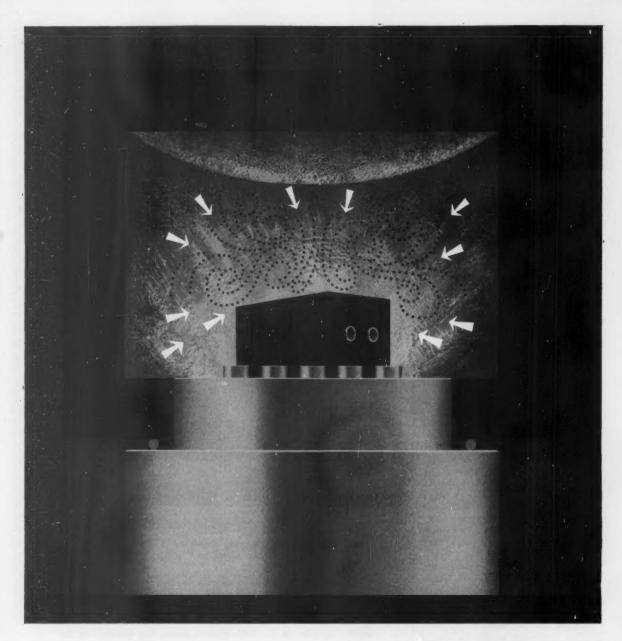


Abrasives Division
ELGIN NATIONAL



WATCH COMPANY

ELGIN, ILLINOIS



LING'S LIGHT-ARMATURE SHAKER LETS YOU

TEST UNDER PRESSURE Altitude, temperature, humidity! To help you conduct vibration tests under such extremes,

Ling brings you the new liquid-cooled Shaker A246 of revolutionary design. In this 7500 force-pound shaker, Ling shaves the weight of the armature to a new low of only 68 pounds—the lightest armature by far for this force-rating. Structural resonance, first major, develops at 2570 cps, bare table. Shaker efficiency is at a new high; the A246 delivers full output at reduced amplifier power, cutting costs on associated electronics equipment. In a chamber, it functions at extremes well above ordinary shakers—from—100°F to +300°F, and up to 125,000 ft. Further, it simplifies chamber testing even more when used with the piggy-back chamber shown above. With Ling seals and baffles, the shaker body acts as one wall of the chamber, and only the table rides into the chamber. This is just one more advance from Ling research; for electronics that always help you out of prototype into production, fast—look to Ling. For details, write Dept. MD-1, at either address below.

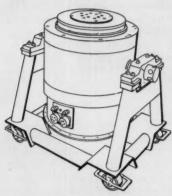
LING ELECTRONICS

A DIVISION OF LING-ALTEC ELECTRONICS, INC. - 1515 SOUTH MANCHESTER, ANAHEIM, CALIFORNIA - 120 CROSS STREET, WINCHESTER, MASSACHUSETTS

The new A246 shaker is but one of the advances growing out of Ling Electronics' continuing program of research and development. This program contributes to the many advantages enjoyed by the Ling customer—fast deliveries, sound engineering and design, ease of maintenance, and the compatibility of Ling environmental testing equipment with other systems.

The compatible design of the A246, for example, permits it to function as part of a test chamber—reducing the size of a chamber needed, and eliminating usual more costly installations. For this method, Ling also supplies a complete line of thermal barriers needed for piggy-back mounting, making combined-environment testing more practical.

Whatever your needs in high-power electronics—for vibration testing, acoustics or sonar—rely on Ling for truly practical design and advanced engineering.



Model A246 SHAKER, which is illustrated above, offers these other performance advantages: 7500 force pound rating, with high first resonance of 2750 cps. Engineered to operate continuously at maximum force on low input. Features simplified compensation over wide bandwidths, dual magnetic field structure for low stray field and improved force-current linearity.



LING ELECTRONICS • HIGH-POWER ELECTRONICS FOR: VIBRATION TESTING • ACOUSTICS • SONAR

Plastic "Frosting" on 707 Gives Icy-Flight Effects

Everywhere it seems, plastics are replacing more familiar materials, even the ice on an airplane wing. To test the effects of severe icing conditions on Boeing's 707, simulated ice was applied to the leading edge of vertical fin and left horizontal stabilizer. Airfoil "slipper" shown here was fabricated from glass-fiber covered styrofoam. The simulated-ice technique gives Boeing a melt-proof method for checking the 707's flight characteristics under an actual ice load. Results of the tests await FAA approval.



Meetings and Shows

May 7-13-

Society of the Plastics Industry Inc. National Conference and Annual Meeting to be held on the Queen of Bermuda. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

May 9-11-

National Fluid Power Association. Spring Meeting to be held at the Grand Hotel, Point Clear, Ala. Additional information is available from Barrett Rogers, executive secretary of NFPA, 5595 N. Hollywood Ave., Milwaukee 17, Wis.

May 9-12-

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Civic Auditorium and Brooks Hall, San Francisco. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 9-13-

American Foundrymen's Society. Castings Congress and Exposition to be held in Convention Hall, Philadelphia. Additional information is available from AFS, Golf and Wolf Roads, Des Plaines, Ill.

May 9-13-

American Society for Metals. Second Southwestern Metal Exposition and Congress to be held at the Sheraton-Dallas Hotel and State Fair Park, Dallas. Additional information is available from ASM, Metals Park, Novelty, Ohio.

May 9-13-

Society of Photographic Scientists and Engineers. Annual Conference to be held at the Miramar Hotel, Los Angeles. Additional information can be obtained from the society, Box 1609 Main Post Office, Washington, D. C.

May 11-14-

American Helicopter Society. 16th Annual National Forum to be held at the Sheraton Park Hotel, Washington, D. C. Further information can be obtained from AHS executive secretary Harry M. Lounsbury, 2 E. 64th St., New York 21, N. Y.

May 11-14-

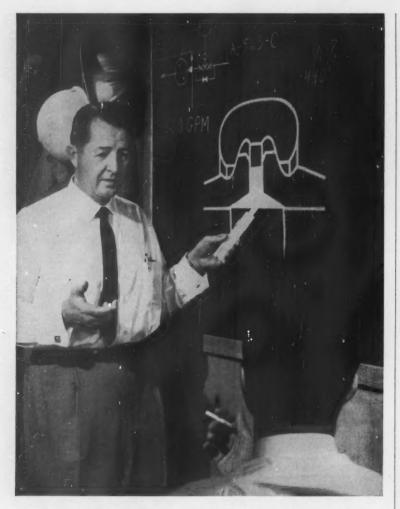
Fluid Controls Institute Inc. Spring Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from E. R. Rath, P. O. Box 667, Pompano Beach, Fla.

May 17-19-

American Society of Mechanical Engineers. Production Engineering Conference to be held at the Hotel Schroeder, Milwaukee. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

May 18-20-

Society for Experimental Stress Analysis. National Meeting to be held at the Hotel Severin, Indianap-



New GRAYLOC® Seal Eliminates Leaks

GRAYLOC is practical where leakage is a problem, regardless of high or low pressure, where savings in money, space, weight or time are desirable.

The Grayloc seal design, a new principle in pipe connection, is simple: tapered lips on either side of a rigid rib. The seal lip tapers slightly less than the mating hub, forming a line seal as the components touch. As the connection bolts are tightened, the lips deflect to form a positive, leak-proof surface seal. Grayloc Connections can be made and released repeatedly and still operate to pressure without seal ring replacement.

GRAYLOC works in most flange applications. If you are interested in more information about how GRAYLOC can solve your leakage problems and save you money, write for the new GRAYLOC CATALOG on your company letterhead. No charge, no obligation.



P.O. BOX 2291

HOUSTON 1, TEXAS

REpublic 4-1641

olis. Further information is available from society headquarters, P. O. Box 168, Cambridge 39, Mass.

May 22-26-

American Society of Mechanical Engineers. Oil and Gas Power Conference and Exhibit to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

May 23-25-

Ninth National Telemetering Conference to be held at the Miramar Hotel, Santa Monica, Calif. Conference is sponsored by Instrument Society of America, American Institute of Electrical Engineers, American Rocket Society, and Institute of Aeronautical Sciences. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 23-26-

Design Engineering Show and Conference to be held at the Coliseum, New York. Conference is sponsored by the Machine Design Div. of ASME. Further information can be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 23-27-

American Textile Machinery Association. International Exhibition to be held at Convention Hall, Atlantic City, N. J. Further information is available from ATMA executive secretary, Mildred B. Andrews, P. O. Box 596, Vienna, Va.

May 26-28-

Society of Naval Architects and Marine Engineers. Spring Meeting to be held at the Statler Hilton Hotel, Washington, D. C. Further information is available from SNAME, 74 Trinity Place, New York 6, N. Y.

June 5-9-

American Society of Mechanical Engineers. Summer Annual Meeting and Aviation Conference to be held at the Statler Hilton Hotel, Dallas. Additional information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

June 5-10-

Society of Automotive Engineers Inc. Summer Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information can be obtained from SAE, 485 Lexington Ave., New York 17, N. Y.

June 6-7-

Malleable Founders Society. Annual Meeting to be held at the Elbow Beach Surf Club, Hamilton, Bermuda. Further information can be obtained from society head-quarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

June 6-8-

American Gear Manufacturers Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. Further information is available from AGMA headquarters, 1 Thomas Circle, N.W., Washington 5, D. C.

June 8-11-

National Society of Professional Engineers. Annual Meeting to be held at the Statler Hotel, Boston. Additional information can be obtained from NSPE headquarters, 2029 K St., N.W., Washington 6, D. C.

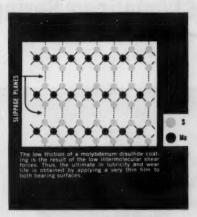


"I'm turning this job over to you, Winters—that'll give you some idea of how desperate we are."

MoS2+

FORMULA FOR TOMORROW'S LUBRICANT

One-time lubrication . . . permanent, dry lubrication . . . applied with the greatest of ease to virtually any type of material—that's just a small part of the amazing story of what Poxylube can do for you.



Poxylube replaces conventional greases and oils, does away forever with the need for lubrication, and can be bonded permanently to structural metals, metal products, wood, plastics and glass. Poxylube can be applied by spraying, dipping or brushing, with

no surface pre-treatment except degreasing.

Poxylube performs! It supports pressures up to 90,000 psi, operates in temperatures between -100° F. and +500° F., and has a coefficient of friction range of from .08 to 0.1. It's effective in thicknesses between .0001 and .0004 inch.

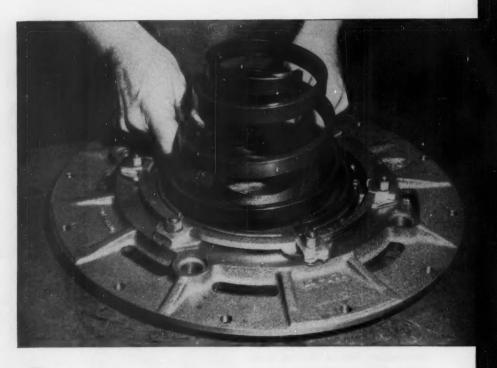
How does Poxylube do it? The molybdenum disulfide pigment making up most of the Poxylube film consists of a multitude of flat laminar platelets—40 molecular layers to a millionth of an inch—of alternating molybdenum and sulfur atoms. These layers permit approximately 39 slippage planes to a millionth of an inch... thus achieving high film strength and adhesion.

Whether you're lubricating eggbeaters or engines, hinges or helicopters, Poxylube can help you do the job better, permanently, and at less overall cost. Poxylube is currently being used in major missile and space projects. Write for information today.

Pioneering in Industrial Dry Lubricants



POLY CHEM • 541 South Webster Avenue, Indianapolis 19, Indiana



USS American Springs give longer life,



In the AS&W Spring Laboratory a semi-resonant spring fatigue machine is testing the Lipe-Rollway clutch spring. At speeds of 700 cpm this spring is functioned beyond its normal life span and at higher than normal stresses to prove conclusively its superior design as a clutch spring.

A USS American flat wire compression spring is shown in place in the Lipe-Rollway clutch. Four round wire compression springs are also being installed in the clutch.



better performance in heavy-duty clutches ...thanks to AS&W Spring Engineering Research Service

The Lipe-Rollway Clutch Division, Lipe-Rollway Corporation, Syracuse, N. Y., manufactures automotive clutches for heavy-duty trucks, tractors, buses and other large mobile equipment. Because USS American Springs play a vital part in the performance of these clutches, Lipe-Rollway asked the AS&W Spring Engineering Research Service to test the springs and determine if any changes should be made in the design to improve and maintain the high performance standards.

As a result of these tests the AS&W Engineers recommended certain important changes to give the springs longer life. After this recommendation was adopted by Lipe-Rollway, Mr. Harvey Gray, Chief Inspector & Quality Control, had this to say: "Exceptional service has been realized from our American Steel & Wire Springs."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general office in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels-from steel chemistry through product applicationto more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal.

American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.

USS and American are registered trademarks

American Steel & Wire Division of



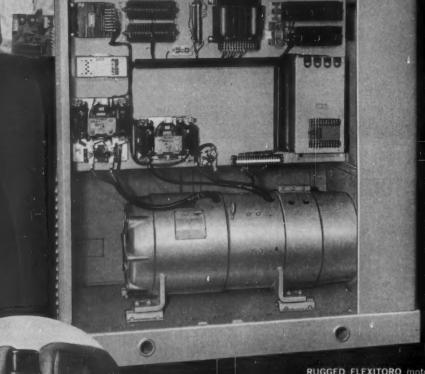
United States Steel

Columbia-Geneva Steel Striolon, San Francisco, Pacific Coart Sistributura . Tennessus Coal & Iron Sivision, Fairfield, Ala., Southern Bistributura . United States Steel Export Company, Sighthultura Abraud



FINGERTIP OPERATOR CONTROL with start and stop pushbuttons and potentiometer speed setting dial. Small potenti-ometers greatly reduce size of operator's control panels and are dust-tight for max-





DEPENDABLE TRANSISTORS are heavy duty indushalf their nominal rating in our circuits. They have never fade — normally provide 15 or more years of dependable service.





It's ideal for single-motor and synchronized multi-motor drives for:

Extruders
Wire-drawing machinery
Machine tools
Conveyors
Calenders
Paper machinery
Textile machinery
Printing presses
Test stands
Adjustable frequency
power supplies
and many other applications

Another NEW product from Louis Allis

The New LOUIS ALLIS Select-A-Spede® Drive —First with field-proved All-Transistor Control

a high-gain, high-performance d-c drive with unmatched flexibility and low upkeep

Here's a superior adjustable speed drive with simplified transistor—magnetic amplifier control. It's the easiest drive to set up and operate. A twist of the dial gives you stepless speed adjustment from zero to full speed in either direction. Each adjustment is independent, thus sparing you the need for compensating adjustments of inter-related settings. You get more consistent day to day operation because transistors—unlike tubes—are highly dependable.

The new Select-A-Spede defies obsolescence. To add functions, such as current limit, to your basic drive, you simply have your electrician install the "current limit" transistor circuit panel. These "building-block" panels allow you to add any of the 13 control circuits that changing conditions call for — and they are immediately available from Louis Allis stock. Thus a rebuilding or adaptation job that, on former equipment, cost thousands of dollars — excluding down-time — can now be done at a fraction of the cost and time right in your own plant!

Transistor control practically eliminates upkeep and down-time. High quality transistors, field proven in missiles and other advanced electronic equipment, assure you of a high degree of dependability with a life expectancy of 15 or more years. Printed low-voltage transistor circuits are virtually trouble-free and can be quickly and easily replaced from low-cost stock.

Further savings are provided by the new Louis Allis Flexitorq® drive motors through vastly improved commutation, low brush wear, and their ability to safely withstand momentary overloads of 400% of normal horsepower rating.

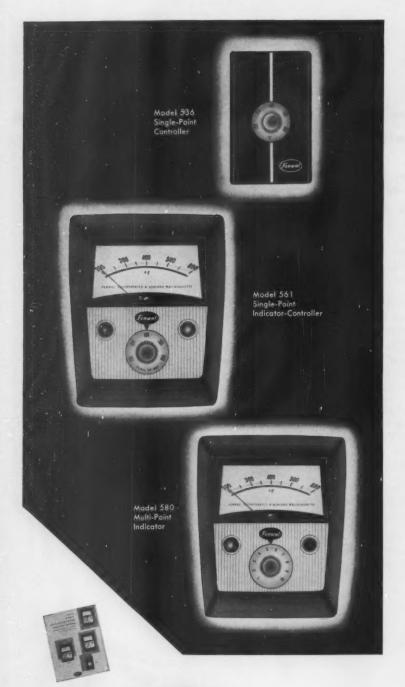
If you want superior speed regulation on your drive, check the new Louis Allis Select-A-Spede with all-transistor control. Sizes from 5 to 400 hp—in a wide range of enclosures and speed ranges up to 20:1. Contact any one of the 60 Louis Allis District Offices for information and application assistance. Or write for bulletin 2001 to The Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wisconsin.



MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

NOW... A <u>Better Match</u> for Temperature Control Requirements...



Here's the brand-new family of Fenwal Transistorized Temperature Controllers that lets you order only what you need. In addition, you obtain functions previously unavailable in thermistor controllers. These additions to the "500 Line" permit precise matching of control instrument to application over a temperature range from -50 to +600°F.

Thermistor sensors and rugged, reliable transistorized circuits assure long life and trouble-free operation . . . and eliminate lead wire problems. Every instrument is easily installed . . . in the plant or on the machine. Professionally styled cases and wide choice of colors blend with the most modern surroundings. And, best of all, advanced Fenwal design and production methods keep costs reasonable! Here are three examples:

The Model 536: reliable, single-point controller gives you these options: ON-OFF or proportioning control...set-point adjustment in the instrument or remotely located... indication as well as control... expanded scales for fine temperature adjustment. And you pay only for the option you need. Capacity of 10 amp/110 VAC and 5 amp at 230 VAC.

The Model 561: single point indicator-controller designed for panel mounting. Panel button permits meter display of temperature set point. Control and indication circuits are independent. Mirror-backed scale prevents parallax, tilted glass cover reduces reflection. Option of either ON-OFF or proportioning control. 10 amp/110 VAC relay capacity... insensitive to voltage fluctuations.

The Model 580: multi-point indicator permits "flick of a switch" indication of 2 to 10 temperatures controlled by up to ten Model 536 con-

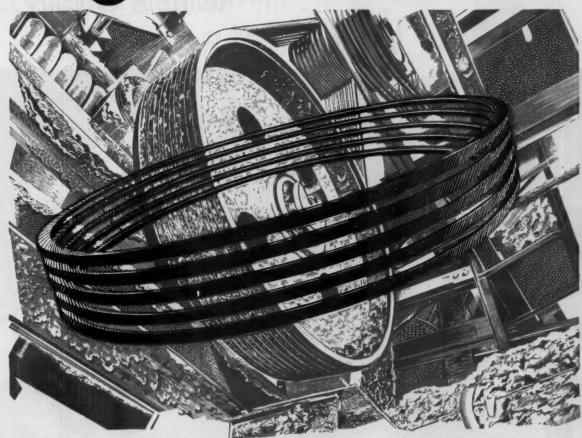
These are just the high spots. For complete details on this versatile Fenwal family, send for bulletin MC-190, "Smarter Looking Smarter Acting Electronic Temperature Controls." FENWAL INCORPORATED, 194 Pleasant Street, Ashland, Mass.

Another example of how



CONTROLS TEMPERATURE . . . PRECISELY





"Swinging Loads" demonstrate how

balanced driving power pays off

The flywheels on stone-crushing machinery at the Bethayres Concrete Products Company in Bethayres, Pa., put V-belts under a "tremendous strain."

Not only must each set of 8 U.S. Royal V-Belts driving the flywheel operate under extremes of abrasive conditions, it must also operate on constantly changing centers. As incompressible foreign matter enters the driven rollers, they swing or oscillate to allow passage. The result is constantly changing tensions under pressures amounting to many tons!

Yet even with this constant change in tensions and the severity of the abrasive conditions, the U. S. Royal V-Belts continue to share the load for an average of one year of rock-breaking service.

The C-210's used on these V-sheave to flat-surface drives,

like all of the approximately 250 "U.S." belts in 48 different sizes used throughout the Bethayres plant, have a built-in advantage. "Balanced driving power"... the result of specially developed manufacturing equipment that automatically controls weight, dimensions, density, length, and tension members... helps provide a uniformity, toughness, length stability and true-running smoothness that have paid off in job after job, plant after plant the nation over.

Put balanced driving power to work in your own operations. See your "U. S." Power Transmission Distributor for full stocks and expert service.

U. S. Royal V-Belts and engineering assistance for these drives supplied by "U. S." Distributor Lindsay-Oberholzer of Philadelphia, Pa.

Visit Booth 1324, Design Engineering Show, New York Coliseum, May 23-26.



Mechanical Goods Division

United States Rubber

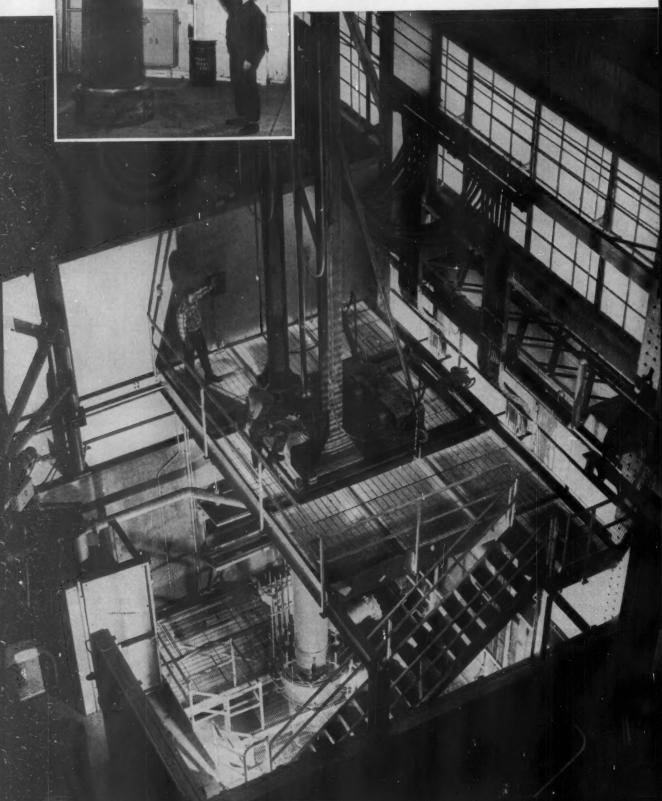
WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y.

In Canada: Dominion Rubber Company, Ltd.



Reliable Quality...



In Quantity...On Time...

REPUBLIC **VACUUM-MELTED METALS**

Now produced in up to 20,000-pound heats!

For applications where reliability is of major importance, Republic offers vacuum-melted metals in ingots, billets, sheets, bar, strip, and wire.

The most extensive facilities ever assembled permit rapid delivery of vacuum-melted metals in quantity and in a wider range of sizes and conditions than ever before possible. Republic is producing vacuum-melted ingots weighing from 4,000 to 20,000 pounds in 18- to 32-inch diameters. Metals available include: super alloy steels, constructional alloy steels, high strength alloy steels, bearing steels, special carbon steels, stainless steels, and titanium.

Republic uses the consumable electrode vacuummelting process. Metals thus produced offer higher mechanical properties-ductility, tensile strength, and fatigue life. Non-metallic inclusions are reduced in number and size. Testing, certification, job setup, and production costs are reduced.

Our metallurgists and engineers are available to help you select, apply, and process the vacuummelted metal best suited to your requirements. For complete information, contact your nearest Republic sales office today or return the coupon.

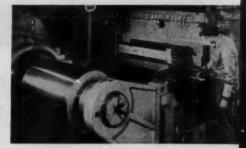
Super Alloy Steels . Constructional Alloy Steels . High Strength Alloy Steels . Bearing Steels . Stainless Steels . Titanium . Special Carbon Steels.



BILLETS-Republic's 3000-ton forging press converts vacuum-melted metals to large billets that are ideal for forged parts manufacture. Segregations associated with dendrite freezing are greatly reduced by the consumable electrode process and further alleviated by the greater hot work reduction ratios permitted by large ingots.



BARS-Vacuum-melted metals are converted into close-tolerance squares, rounds, hexes, and many other shapes on Republic bar mills. Virtually any size can be produced—from 1/4" to 10" rounds and equivalent footweight sections. These bars offer improved ductility, tensile strength, fatigue life, and resistance to scaling.



SHEETS-Vacuum-melted stainless, titanium, and super alloy steels are converted to light gage sheet and strip on Republic's Sendzimir mills. Large coils up to 48" (36" maximum on titanium) wide are produced to close tolerances with excellent finishes and strength-to-weight ratios. Sheets up to 72" wide can be produced on hand mills.



REPUBLIC STEEL

WHERE STEELS ARE MADE TO MEET THE CHALLENGE OF ACCELERATION

Circle 432 on Page 19

REPUBLIC STEEL CORPORATION DEPT. MD -9240 1441 REPUBLIC BUILDING . CLEVELAND 1, OHIO

- ☐ Please send more information on Republic Vacuum-Melted Metals

☐ Have a metallurgist call

Company___

Zone_State_



Complete Message Center in one Teletype Machine

A complete message center in a compact cabinet, with a choice of components to best meet your individual needs—that's the story of the Teletype Model 28 automatic send-receive set.

It provides facilities for sending and receiving on message paper or sprocket-fed business forms. In addition, there is a choice of four different tape reader and four different tape punch components—for preparing punched tape and for sending and receiving with tape.

The flexibility of the set is further broadened by a built-in control unit, the "stunt box," which may be equipped for a wide variety of extra features and switching duties—eliminating the need for external apparatus often required for such functions.

The ASR set is a compact, efficient tool to speed communications and cut costly paperwork. Why not investigate what it can do for you?



Typing Tape Punch





Send-Receive Page Printer Automatic Send-Receive Set

FREE LITERATURE: Write for Model 28 "Complete Product Line" brochure Teletype Corp., Dept. 28D 4100 Fullerton Ave., Chicago 39, Illinois.



See Teletype Corporation's equipment exhibit at the Western Joint Computer Conference, May 3-5, San Francisco, California.

Product Improvement Ideas

from WARNER

"Control innovations
made possible by
Warner electric clutches
open new markets
for Gisholt"

E. N. Wackwitz, Design Engineer
Gisholt Machine Company, Madison, Wisconsin



Electric motion control



Gisholt pyramids product improvements from Warner electric clutches

Even though tax laws say the test of time governs economic life of capital equipment, smart marketers like Gisholt Machine Company know that better machines will justify replacement and increase their sales.

That's why E. N. Wackwitz, head of Fastermatic engineering, set up both engineering and economic criteria for the new turret lathes Gisholt introduced in 1955.

The old Fastermatic was underpowered, not fast enough, and too light for modern machining. But more brawn was not the complete answer for Gisholt. The design team looked at the customer's problem-saw the cost-price squeeze he was in, and set out to develop a machine that would lead the market. This, at a time when industry was heading into automation and tape control.

50% faster setup through switches

Out of this analysis came a new type of turret lathe, boldly festooned with neat rows of toggle switches to control all important machine functions automatically-a machine that can change its own speeds and perform other functions in accordance with information fed into it by switch settings. Result: 50% faster setup, easier operation, more work on the floor at the end of the day. Gisholt found new control concepts they needed in Warner electric clutches capable of producing instant, automatic speed changes under high torque conditions. Four spindle speeds, controlled by energizing the right combination of clutches, are masterfully designed into the headstock gearing. Best speed can be preset for each operating sequence. Electric clutches produce high torque per square inch-permit mounting on short, stiff shafts. There are no sliding gears or complex actuating devices.









As pointed out by E. C. Helmke, Chief Engineer, direct electrical actuation eliminates cams, dogs, and other gingerbread controls.

Control-ability widens the market

Gisholt is out to give the customer wider work range for his money. Vice President G. M. Class quickly points out that the automatic clutches and constant-mesh gears permit changing speeds without stopping the machine. Thus, optimum stock removal rates can be maintained when facing or contouring.

General Sales Manager R. H. Bruce appraises marketability of the new Warner-equipped Fastermatic this way. With the preselect panel and faster setup, it is now economical to machine short-run jobs formerly done on hand-type turret lathes. For customers who want to control production from the front office, all motions, including longitudinal feed of the turret and transverse motion of the cross slides, may be wired into a punched card or tape system.

From a manufacturing standpoint, John Murray, Supervisor of Assembly, likes the new headstock because assembly is easier. Thrust loads are on the front wall. The actuating system is a simple wiring job. Very little inspection and no run-in are necessary for the Warner clutches. In fact, no power is applied until the machine reaches the test floor. Cushioned reaction, adjustable by rheostat, saves wear and tear on machine parts.

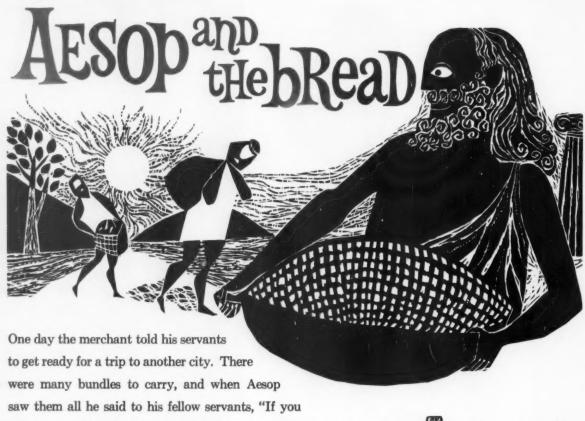
Warner has geared its operations to the problems of machinery builders. Power transmission distributors carry replacement parts in all manufacturing centers. These requirements are watch-dogged by F. C. Huegel, Purchasing Agent, and J. L. Menhall, his assistant. Purchasing plays an important marketing function as well. Warner engineers are encouraged to work closely with Gisholt people to assure maximum co-ordination.

Machine tool buyers look at controls first, so why not put proved performance where your customers see it?

Electric motion control by Warner is pioneering new concepts in machine design. Improved synchronization, rapid cycling, fine inching and jogging, tension control, no-load starting, rotary indexing and linear positioning, foolproof interlocking, and other articulate functions can make any machine more valuable to the user . . . at the same time reduce cost by eliminating unnecessary parts. That's why a Warner sales engineer can be a valuable contributor to your product improvement program.

WARNER

Warner Electric Brake & Clutch Co. Beloit, Wisconsin cleverness wins



let me carry the lightest bundle, I'll tell you many fine stories as we walk." The servants agreed because they liked Aesop's stories. But when Aesop picked up the heaviest bundle of all—a large basket of bread — the other servants laughed at him. He barely could manage to carry it. Around noon, the travelers stopped to rest and eat their dinner. Aesop gave each servant a loaf of bread for dinner, so the big basket wasn't as heavy during the afternoon. When the sun went down, Aesop gave each servant a loaf of bread for supper, and the big basket was empty. The next day the merchant and his servants went on to the city. Aesop had nothing to carry but his empty basket, so he told stories to the other servants while they struggled under their loads.

moral: Alert analysis wins out in the end.

Have you analyzed your machines to make sure that proper cylinder designs are providing most efficient production? Ask your Hydro-Line representative to help you. Of course, he might try to sell you a Hydro-Line cylinder or two, but only if you really need them. And his analysis now may save you considerable time and money later.

Your Hydro-Line representative will recommend standard stock cylinders if he can . . . they have all catalog stock dimensions, cost you less, and can be delivered immediately. If a stock

cylinder is unsuitable for your application, he'll recommend the proper modified standard cylinder, which has its own stroke or other deviations from catalog stock dimensions. Either way, you can be sure that the best cylinder design is working to help you gain more production and earn more profits.

Look in Sweet's Product Design File (Bulletin 8a-Hy) for standard dimensions of stock cylinders and the address of your nearest Hydro-Line representative. Ask him to analyze cylinder requirements in your plant soon.



HYDRO-LINE CYLINDERS



5600 PIKE ROAD, ROCKFORD, ILLINOIS manufacturers of: high- and low-pressure hydraulic cylinders

duty air cylinders

adjustable-stroke cylinders

dispensing cylinders

intensifiers

single-acting cylinders

booster cylinders

Why metals corrode...and how you can prevent it

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide. Six forms of corrosion which can attack the equipment you design are:

- 1. General tarnishing or rusting with occasional perforations in highly affected areas.
- 2. Highly localized attack by pitting.
- 3. Cracking induced by a combination of stress and corrosion.
- 4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.
- 5. Corrosion of one of an alloy's constituents leaving a weak residue.
- 6. Corrosion near the junction of two different metals.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

The electrolyte in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

The plates of the battery correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

Briefly then, for corrosion to occur, there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

When you plan against galvanic corrosion it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

GALVANIC SERIES TABLE

Magnesium Magnesium alloys Zinc Aluminum 25 Cadmium Aluminum 17ST Steel or Iron, Cast Iron Chromium-iron (active) Ni-Resist 18-8 Stainless (active) 18-8-3 Stainless (active) Lead-tin solders Lead, Tin Nickel (active) Inconel (active) Brasses, Copper, Bronzes Copper-nickel alloys, Monel Silver solder Nickel (passive) Inconel (passive)

HOW TO USE THE CHART

Chromium-iron (passive)

18-8 Stainless (passive) 18-8-3 Stainless (passive)

Silver

Graphite, Gold, Platinum

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

When you plan against local action, remember that the corrosion process is galvanic: Electrons move from one point in the metal to another. One of the easiest ways to prevent local action is to use a metal with little or no impurity. When alloys are involved, make sure the constituents are closely listed in the galvanic series table. Local action may also be stopped by the use of protective coatings, which shield the metal from the corrosive media. Environment must also be considered, for its nature may be an important factor in either promoting or restricting corrosion.

TECHNICAL ASSISTANCE

As you can see, many factors are involved in both local and galvanic action. That's why it's best to bring your metal problem to Inco's Corrosion Engineering Service. Available data will be furnished wherever possible . . . tests will be made where needed. Inco's Corrosion Engineering Service will be glad to apply principles of corrosion control to your specific problem.

LITERATURE

The publications listed below will provide more detailed information on how you can combat corrosion by using nickel-containing metals.

Publication
Number Name
A232 . . . Corrosion Problem

A232 . . . Corrosion Problems in Nuclear Reactor Power Stations A59 . . . Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels

A62 A Theory of the Mechanism of Rusting of Low-Alloy Steel in the Atmosphere

A137 . . . Corrosion by Some Organic Acids and Related Compounds

A144 . . . Some Observations of the Potentials of Stainless Steels in Flowing Sea Water

A complete list of the 187 Inco publications and technical bulletins on nickel-containing metals can be obtained by writing for "List A", to:
**Registred trademark

The INTERNATIONAL NICKEL COMPANY, inc. 67 Wall Street New York 5, N.Y.

HOW THE ENGINEERING SERVICES OF

Central Foundry

help you design better castings at lower cost

Many new developments here at Central Foundry have broadened the field of application for castings and have given design engineers greater latitude. To assist you in exploiting these new methods and materials to fullest advantage, each of our engineering departments—design, experimental, process and metallurgy—is at your disposal. Central Foundry is also using a number of testing techniques such as stress analysis, cobalt radiography and sonic testing, that

have proven invaluable in lowering the cost and improving the quality of castings. These procedures help us to determine the best design and method of producing a casting, either by the green sand method or the shell mold process, and the best material for the casting, either grey iron, malleable iron or ArmaSteel.

Central Foundry has the capacity to deliver, on schedule, quality castings in production quantities.

STRESS ANALYSIS FOR IMPROVED DESIGN

An important part of our engineering services is the stress analysis laboratory. Stress analysis discovers the amount of stress on a part due to its service function and is an important aid in determining and improving the strength of a part. Improved casting design can be accomplished through the use of stress-analysis by more effectively distributing the metal in the part. The U-bolt anchor plate

shown here is a case in point. Our customer was experiencing failures in this part and asked us to see what we could do to solve the problem. Using stress analysis the part was completely redesigned for maximum efficiency. The redesigned part is 35% stronger, 42% lighter and less costly.



EXCELLENT MACHINABILITY FOR INCREASED PRODUCTION

AACHINABILITY RATING (PER CENT)

50 60 70 60 90 100 110 12

ETANDARD MALEFABLE IRON-BRINELL HARDNESS 110-148

S.A.E. 1022-BRINELL HARDNESS 159-192

S.A.E. 1112-BRINELL HARDNESS 159-192

S.A.E. 1112-BRINELL HARDNESS 189-229

S.A.E. 1040-BRINELL HARDNESS 179-229

CENTRAL FOUNDRY DIVISION



REDESIGN FOR STRENGTH

This is a rear spring clip pad that was converted to a casting with the help of stress analysis. The clip pad supports the shock absorber arm and clamps the spring to the rear axle of an automobile. When produced as a stamping, this part weighed 4-1/4 pounds. However, when designed as an ArmaSteel casting, weight was reduced to 2-9/10 pounds. Most important, based on comparative stress analysis tests, the casting is 30% stronger than the stamp-

analysis tests, the casting is 30% stronger than the stamping. (In addition, the holes are produced by the foundry, making it unnecessary for the customer to punch them.) This conversion from a stamping to a casting resulted not only in increased strength, but in substantial cost savings, as well.



REDESIGN FOR IMPROVED PRODUCT AND ECONOMY

Many of our customers have found that redesigning a product to be made as an ArmaSteel casting rather than as a fabrication, forging or stamping, has resulted in a better part at less cost. The fabricated design of a rear wheel truck hub at the left consists of a forged base with a steel plate welded in place to form the smaller flange. The casting on the right, designed jointly by the customer and our engineers, is of single piece construction, is lighter, stronger

and less costly than the fabricated design and eliminates the fitting and welding of the small flange.





FABRICATED DESIGN

ARMASTEEL CASTING

PROCESS ENGINEERING FOR LOWER COST

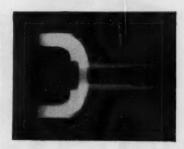
Our process engineers are continually looking for ways to more economically produce castings, thus lowering the finished-product cost. Shown here is a single casting that combines 5 bearing caps used on a V-8 engine. The casting is almost completely machined as a single piece, and the parts are then separated in a final operation. Substantial savings are realized in both casting and machining costs.



COBALT RADIOGRAPHY FOR ASSURED QUALITY

Radiography, by means of Cobalt 60, has drastically reduced the time required to check castings and is an important aid in obtaining the best possible casting quality. In an effort to eliminate a machining operation on the universal joint yoke shown here, a design change was made in the tube section of the part. When sample castings of the new design were checked radiographically,

it was immediately apparent that the design was unsatisfactory since it caused acute metal feeding problems. By redesigning and further checking by radiography, Central Foundry was able to produce, in the shortest possible time, a lighter casting which required less machining in our customer's plant.



SHELL MOLDING FOR GREATER ACCURACY

Shell molding, a relatively new process of making castings, is now being employed extensively for fast, simple production of complicated castings, such as those requiring narrow, accurate passages and cross sections. It is practically impossible to produce certain parts in any other way without prohibitive costs; this is especially true of ferrous metals. Complicated parts like the manual control valve body shown here, a part

valve body shown here, a part of the automatic transmission of a military vehicle, are readily cast in grey iron when the shell process is utilized. The part had been considered as an aluminum die casting, but was thought unsatisfactory because of adverse expansion and wear characteristics. In this case, meeting the requirements for very close tolerances on the thickness and location of ports was made possible by the shell molding process.



REDESIGN FOR WEIGHT REDUCTION

Vehicle weight reduction is a matter of increasing importance to design engineers . . . and more and more existing parts are being converted from a low or medium to a high strength ferrous material such as ArmaSteel. On the left is a grey iron differential carrier currently used in an automobile. By taking advantage of the superior physical properties of ArmaSteel, it was possible to design the part on the right which is five pounds lighter. The modulus of elasticity of ArmaSteel is approximately 60% greater (the tensile strength about twice as great) than the grey iron material.





90



GENERAL MOTORS CORPORATION

SAGINAW, MICHIGAN

DEPT. 14



TOPS FOR CAPSSUPER DYLAN® high-density polyethylene

bon am



These aerosol can caps for two well-known products are molded by Gilbert Plastics from Super Dylan high-density polyethylene. This tough, strong plastic is durable, will not chip or dent. The unique cap design protects the spray nozzle and makes the cans easy to stack, saving valuable counter display space.

SUPER DYLAN is dimensionally stable, light in weight, rustproof, and chemically inert. It has a smooth, glossy finish and can be molded in any color desired. Its ease of molding makes it possible to create caps for any size or shape of can.

SUPER DYLAN is "tops" as a packaging material. It can be molded into bottles and jars for liquids and semi-solids—in colorful, decorative and utilitarian closures for cosmetics and pharmaceuticals—or extruded as boilable, freezable SUPER DYLAN film for food packaging. For more information, write to Koppers Company, Inc., Plastics Div., Dept. MD-402, Pittsburgh 19, Pennsylvania. Offices in Principal Cities, In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario.

KOPPERS PLASTICS



Molder: Gilbert Plastics, Inc., Kenilworth, N.J.

GEARS FOR EVERY PURPOSE

Throughout the world-wherever gears are used—ILLINOIS GEARS have a matchless reputation for dependability and superiority that is constantly being proven by their performance in such equipment as this mammoth Kolbe Wheel Excavator designed by the United Electric Coal Companies.

One can well imagine the enormity of engineering work required to design and build this giant earth mover and the responsibility of the components which include numerous ILLINOIS GEARS, in assuring its successful operation.

If you want gears that are made right, with quality as the first consideration, specify and buy ILLINOIS GEARS. Ask for full information today.

Machining the large spur gear for driving the digging wheel of the huge

Kolbe Excavator.

It takes 3500 cubic yards of earth an hour to satisfy the powerful appetite of this Kolbe Wheel Excavator which is clearing the overburden from a coal strip near Canton, Illinois.

Look for this mark (LL) ... the symbol on finer gears

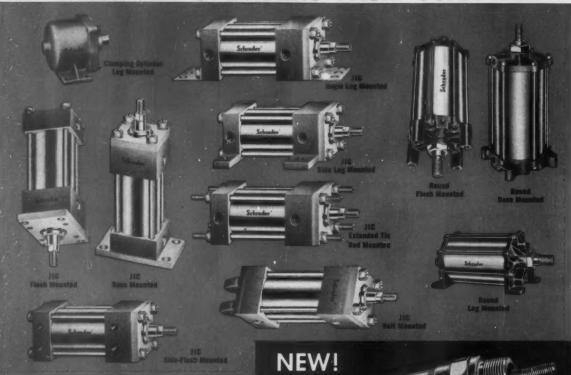


Gears for Every Turpose ... one gear or 10,000 or more

S GEAR & MACHIN

2108 NORTH NATCHEZ AVENUE . CHICAGO 35, ILLINOIS

ALL THESE AIR CYLINDERS FROM SCHRADER...



Schrader offers complete lines of double-acting and single-acting air cylinders in 9 bore sizes, with or without cushioned strokes, including JIC cylinders, all in a variety of mountings. They make hard work easy ... provide powerful push, pull, lift or reciprocating movements ... and are at work by the thousands in countless plants everywhere.

... AND NOW... POWERFUL NEW MIDGET AIR CYLINDERS

Here they are! Streamlined, compact air cylinders for light duty and gang-type applications...rugged...only slightly thicker than your thumb! Schrader makes them with strength and precision that will give long trouble-free service even in tough applications requiring extra stamina and speed. Simple to use in any position. Excellent for operating jigs and fixtures, transfer and special purpose machines. Features: No tie rods...double-acting...popular 1" bore...stroke sizes to 12".

Your Schrader distributor is fully stocked with all these air cylinders. He is staffed with factory-trained experts who are fully qualified to help you solve any air control problem and select the right air components to perform jobs best. You'll find him in the yellow pages, or write direct.



Schrader's new midget air cylinders have quality built in . . . cartridge type bronze bearing and piston rod seal . . . non-corrodible solid brass end plates with hexagonal flats and noncorrodible brass cylinder and pistons . . . ground and polished steel piston rod . . . molybdenum disulphide grease packing . . . synthetic rubber "U" cup piston seals.



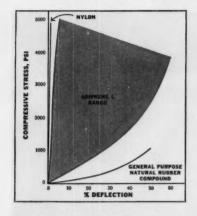
A. SCHRADER'S SON

Division of Scovill Manufacturing Company, Incorporated 476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

ADIPRENE® L

new Du Pont liquid urethane elastomer



CARRIES A HEAVY LOAD An outstanding attribute of this new Du Pont synthetic rubber is its combination of toughness, high load-carrying ability and resilience. Load-bearing capacities of hard Addresse L compounds far excel those of general purpose synthetic rubbers.

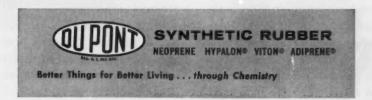
RESISTS ABRASION Both in the laboratory and in actual service, Addrese L has demonstrated its ability to resist wear. On industrial wheels it has outlasted natural rubber as much as 10 times . . . has more than doubled service in pump impellers handling abrasive slurries.





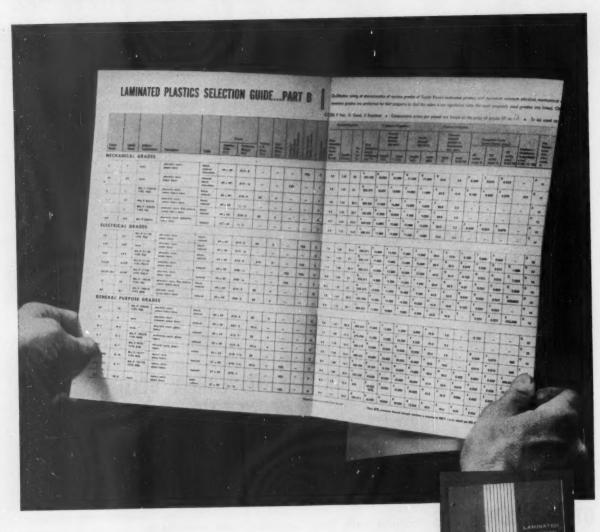
NOT BRITTLE AT "EIGHTY BELOW" ADIPRENE L vulcanizates maintain their resilience at -20° F. . . . and do not become brittle at temperatures as low as -80° F. They exhibit outstanding resistance to thermal shock, and will operate at intermittent temperatures as high as 250° F.

OTHER PROPERTIES Products made from ADIPRENE L are available in various hardnesses from 10 to 99 Shore A (78 Shore D). They resist the action of lubricating oils, greases, weak acids, alkalies, as well as oxygen, ozone and radiation. Suggested uses for ADIPRENE L include industrial rolls, motor mounts, seals, potting compounds, solid tires, striker plates, wear-resistant linings and coverings. Write for booklet on properties and applications of this new material. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-4, Wilmington 98, Delaware.



Important facts to know about laminated plastics

New Guide Developed by Taylor



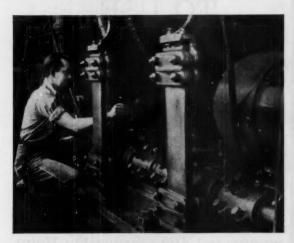
If you have specialized in metals and are considering industrial laminated plastics as a material for certain components in your design for the first time, this newly devised Taylor Selection Guide will help you evaluate the different grades available. The simplified properties chart lists the various grades now produced and clearly indicates the properties in which they excel. An accompanying booklet gives helpful hints on the selection of laminated plastics for your specific application. Write for your copy of this handy Taylor Laminated Plastics Selection Guide today. Use it to make

tentative selections of the laminated plastics that most nearly fit your requirements. Then consult us on the design and application of laminated

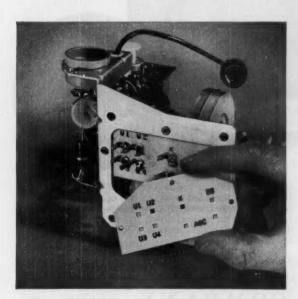
plastics and parts fabricated from them before making a final decision. Our application engineers will be glad to discuss them with you. Write Taylor Fibre Co., Norristown 47, Pa.

Simplifies Laminate Selection

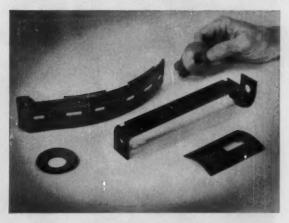
Suggested applications of different grades of Taylor Laminated Plastics



For the fabrication of springs, silent gears, pinions, cams and bearings: Taylor Grade C—a phenolic resin, cotton fabric base, mechanical grade and Taylor Grade L, a phenolic resin, fine weave cotton fabric base grade.



For high-temperature electrical applications and high-frequency radio equipment: Taylor Grade GSC—a silicone resin, glass fabric base, high-heat-resistant electromechanical grade.

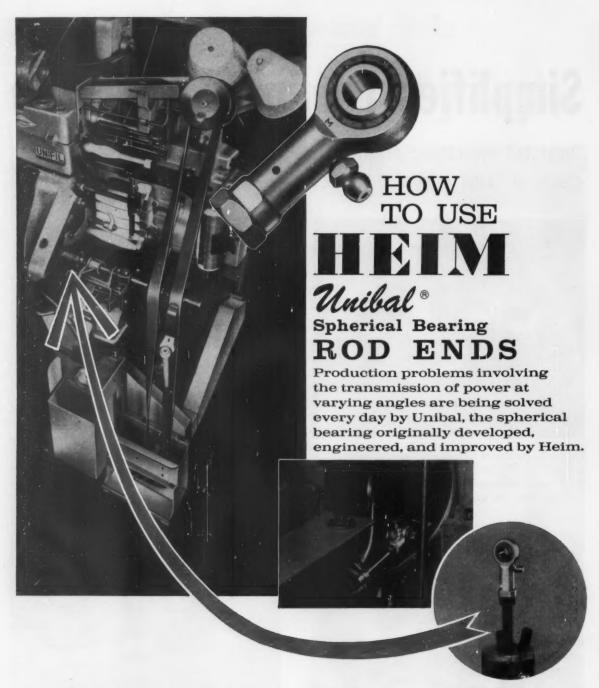


For forming into intricate shapes, compound curves, and deep draws: Taylor Grade C-7—a phenolic resin, cotton fabric base, postforming grade. Also Taylor XX-7—a phenolic resin, paper-base postforming grade.



For applications requiring high-strength retention at elevated temperatures: Taylor Grade GEC—an epoxy resin, glass-fabric base grade.





It is used here as a component of the air pump assembly on the Unifil® Loom Winder made by Leesona Corporation of Providence. This machine is united with the loom to wind the quills, transfer them to the shuttle, strip and return empties to the winder for uninterrupted weaving production. The Unibal Rod End is threaded onto the end of the air pump piston rod, and provides the necessary freedom for an up and down action. Unibal also reduces the skill necessary for a perfect lateral alignment.

Heim, and its sales engineers are ready to offer you any assistance in adapting Unibal to your particular needs. Please write for complete catalog.

THE HEIM COMPANY FAIRFIELD, CONNECTICUT

HEIM BEARINGS ARE SOLD BY THE MOST RESPONSIBLE BEARING DISTRIBUTORS IN THE U.S. & CANADA

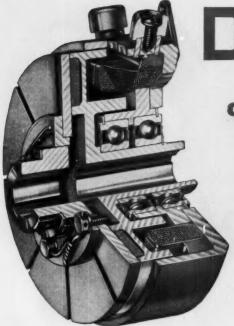
Small Units for Big Jobs! EATON DYNA-TORQ

MAGNETIC-FRICTION CLUTCHES and BRAKES

Now Available in a Full Line from 13/4" to 15" Diameter

Eaton Dyna-torQ Magnetic-Friction Clutches and Brakes provide a simple, accurate, responsive method of controlling power and motion in today's complex production and processing machines.

The smaller sizes and advanced design types of Dyna-torQ Stationary-Field Clutches and Brakes enable Eaton to offer a well rounded line, including flange-mounted and bearing-mounted clutches, and replaceable-face brakes. Unique features of design and construction result in worthwhile maintenance cost savings. Dyna-torQ units, easily and quickly installed on new machines or existing plant equipment, deliver many highly desirable advantages.



STATIONARY-FIELD, BEARING-MOUNTED DYNA-TORQ CLUTCH

Dyna-torQ Magnetic-Friction Equipment Offers these Important Advantages:

- * Accurate power control
- ★ Dependable motion control
- * Rapid response
- ★ Easy "built-in" installation
- ★ Low maintenance costs
- ★ Compact plug-in type controls—may be remotely mounted
- ★ Inter-changeability of parts

Send for this illustrated bulletin giving complete description and specifications covering DynatorQ Stationary-Field Clutches and Replaceable-Face Brakes.





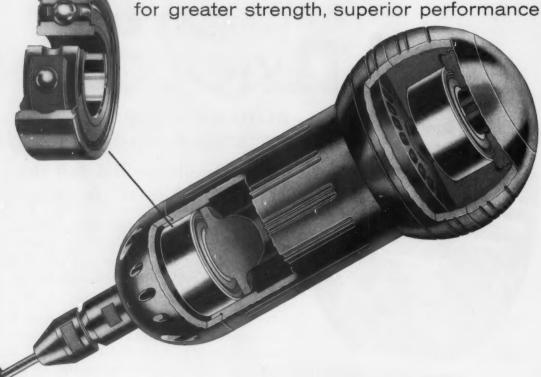
Dyna-torQ Equipment is Available through Dynamatic Distributors in all Leading Cities

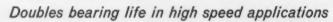
EATON

MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

BARDEN "T" retainer

combines aluminum and phenolic for greater strength, superior performa





Power tools, gyro rotors, aircraft and missile accessories and other high speed applications require bearings that combine high load capacity and endurance at speed. To meet these exacting demands, Barden developed the "T" ball retainer which combines the advantages of phenolic with the strength of aluminum.

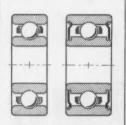
The two-piece "T" retainer has laminated phenolic center sections bonded to high-strength aluminum alloy side plates. It is securely joined by body-bound rivets tightly headed against metal at both ends. The retainer's thin cross section permits maximum exposure of balls and raceways to lubricant. Outer ring piloting provides optimum lubricant circulation.

These features, together with high load capacity, result in longer, trouble-free bearing life. For example, double shielded, grease lubricated "T" retainer bearings have operated continuously in textile spindles for more than 18,000 hours at 30,000 RPM.

Like other Barden advances in engineering and manufacturing, "T" retainer bearings solve a specific performance problem. Other Barden Precision ball bearings satisfy such extreme demands as:

- High temperatures (to above 400° F.) Low torque (to 10 dyne-cm. for 2 lb. load)
- High speeds (to over 300,000 RPM)
 Concentric rotation (to .00005" max. T.I.R.)

The complete Barden line includes sizes from .0469" bore to over 3" O.D., all manufactured to Barden Precision standards of dimensional accuracy, uniformity and reliability. Refer to Sweet's Product Design File (8h/Ba) for Barden catalog and bearing selection guide.



"T" retainer bearings are available in chrome or stainless steel, open or shielded, from .5000" O.D. to 3.3465" O.D. in standard widths. Also available: extra-wide shielded sizes with increased lubricant space for still longer life. For complete technical information write for Engineering Data Sheet T-1.

for reliability...specify BARDEN



PRECISION BALL BEARINGS

THE BARDEN CORPORATION, 208 Park Avenue, Danbury, Connecticut Western office: 3850 Wilshire Boulevard, Los Angeles 5, California



prevents galling prevents seizing protects valuable equipment

GOOP is the amazing new compound for ending the costly galling, seizing and resultant destruction of threaded parts.

The line includes three separate products: Blue GOOP, Silver GOOP and High Purity GOOP.

Silver Goop is formulated to prevent seizing and galling at Ihreaded parts, regardless of applied load, at temperatures up to 2100°F. It reduces take-up torque an threaded parts. Will not drip off red-hot surfaces nor give off poisonous metal or axide fumes at high temperatures. Resists water washout.

Blue Goop is an anti-seize and sealing compound for use on titanium, stainless steel, steel, aluminum

and high temperature alloys. Withstands temperatures up to 400° F. Impervious to water washout, most acids and all petroleum salvents.

High Purity Goop is an anti-seize and sealing compound for titanium, stainless steel, steel, aluminum and high temperature alloys. Withstands temperatures up to 400° F. Impervious to moisture, high voltage and cyclic thermal stress. Recommended for use wherever prevention of product contamination is an important factor.

CRAWFORD FITTING COMPANY

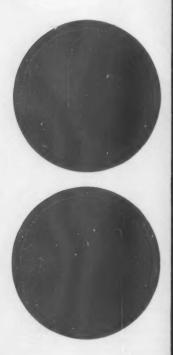
884 East 140th Street

Cleveland 10, Ohio

Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada



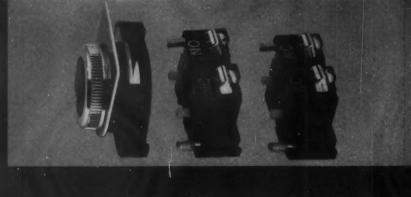
Easily snapped-on plastic caps come in seven colors—red, green, blue, yellow, gray, tan and black—for quick color coding of a push-button bank.



Assembled units (right) permit multiple contacts in limited space. As many as six contact blocks can be coupled to a single pushbutton.

Westinghouse Flush Pushbutton (below) with contact blocks. Notice how one fits directly behind the other. Stacking permits controlling many circuits with one button.





YOU GET... TOTAL DESIGN FLEXIBILITY IN THE WESTINGHOUSE FLUSH PUSHBUTTON

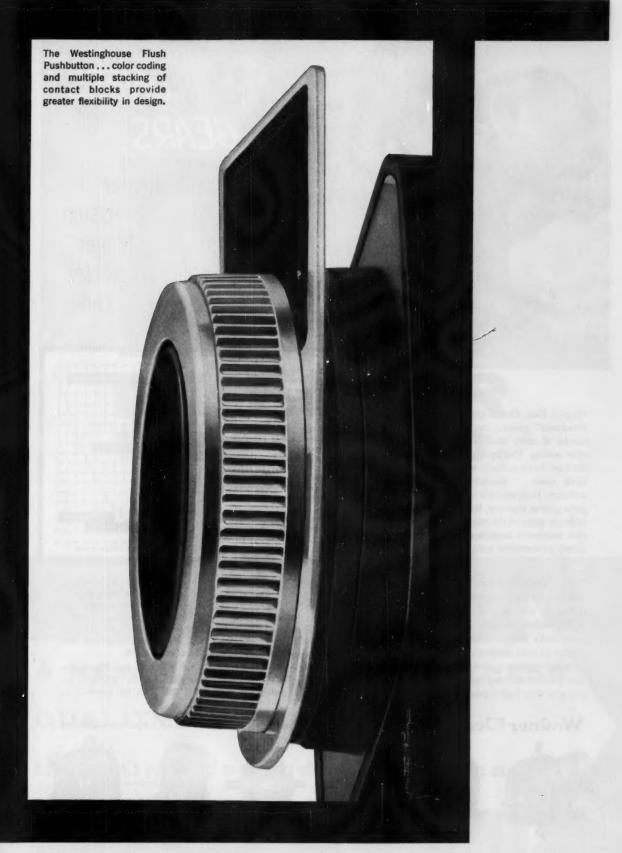
circuit flexibility—unique spacesaving design permits as many as six contact blocks to be stacked one behind the other. You operate all circuits with one push of a button . . . a big help when multiple operations are necessary.

color flexibility—interchangeable chemical-resistant plastic caps come in seven colors: red, green, blue, yellow, tan, gray and black. Choose the best pushbutton for your design and color code it. Permits programming of manual operation using only one model.

function flexibility—choose from a wide range of operators to suit any use. Standard units available include flush head, mushroom head, extended head, selector switches, push-to-test indicating lights and a host of others.

When your design calls for pushbuttons, you'll find what you need in Westinghouse stock. Call your nearest Westinghouse representative, or write Westinghouse Electric Corporation, Standard Controls Div., Beaver, Pennsylvania.

YOU CAN BE SURE ... IF IT'S Westinghouse



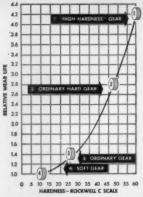


Wagner Gear Drives are built with "High Hardness" gears...made from forged blanks of alloy steel, carefully hardened after cutting. This special process develops file-hard tooth surfaces with tough, ductile tooth cores...maintains close-tolerance accuracy. High strength with high accuracy gives greater capacity, longer wear life than ordinary gears of the same size and weight, plus maximum resistance to shock. Table shows performance comparisons.

2. Ordinary hard gear...hardened after hobbing and shaving. Hardness limited to maintain reasonable accuracy.

3. Ordinary gear . . . hardened before cutting. Hardening limited to maintain machinability.

4. Soft gear . . . excessive size required because of low capacity.

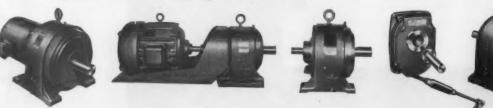


Positive, powerful, slower than motor speeds should mean one thing to you: Wagner Gearmotors. They are built to operate for years at peak efficiency. Advanced design and rugged construction with a minimum number of wearing parts, make this a certainty. Wagner Gearmotors have positive oil seals; continuous lubrication of all moving parts; extra-high capacity bearings; integral bearing housings; and rigid pyramid-mounted cast housings. Extra capacity bearings give them high overhung load ratings, too.

Wagner makes both integral-type and all-motor gearmotors, speed reducers and shaft-mounted speed reducers. They're available in single, double, triple or quadruple reductions ... horizontal or vertical foot or flange mountings. Another important factor: prompt shipment. Standardized components permit immediate assembly of all standard sizes and types; you get equipment when you need it.

Want to know more? Call your nearby Wagner Sales Engineer; he will be glad to help you select the right drive for your application. Bulletin MU-227 gives full information.

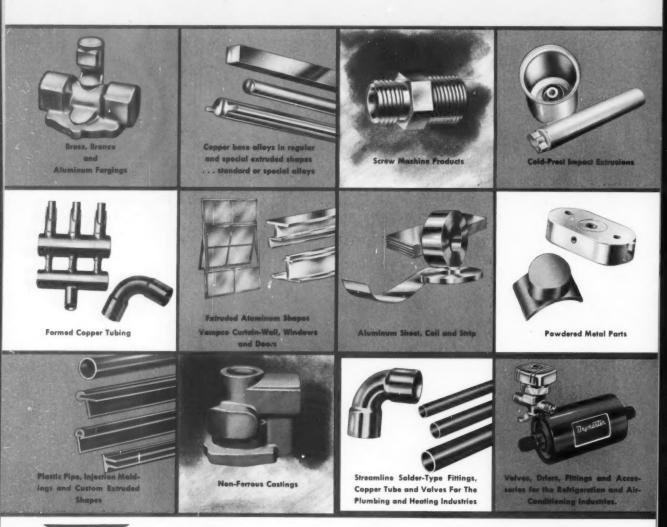
Wagner Electric Corporation 6404 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI





A NEW SYMBOL FOR ALL THESE
QUALITY PRODUCTS
from ONE dependable source

THIS DISTINCTIVE corporate symbol is a new addition to the American business scene and represents the many diversified products made by the Mueller Brass Co. of Port Huron, Michigan, and its subsidiaries. It is a symbol of quality and service and identifies Mueller Brass Co. and its subsidiaries as a dependable source for copper, brass, aluminum and plastic products. Because of its diversified manufacturing facilities that encompass a wide range of fabricating methods, Mueller Brass Co. is in the unique position of being able to offer you, the purchaser, an intelligent, unbiased analysis of the best, most economical method by which your particular part can be produced. For sound design engineering, quality-controlled production and reliable delivery of fabricated parts, make Mueller Brass Co. your one dependable

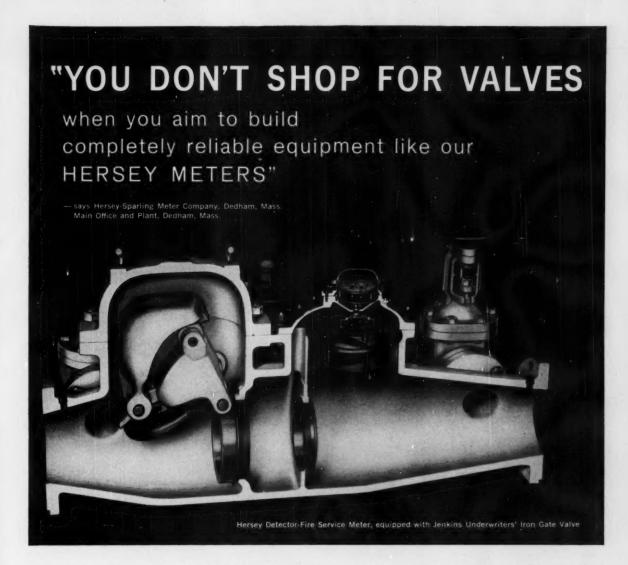




source for all these products . . .

MUELLER BRASS CO., PORT HURON, MICHIGAN

SUBSIDIARIES: VALLEY METAL PRODUCTS COMPANY, PLAINWELL, MICHIGAN; SHEET ALUMINUM CORPORATION, JACKSON, MICHIGAN; VAMPCO ALUMINUM PRODUCTS, LTD., STRATHROY, ONTARIO, CANADA



for 35 years, Hersey Meters have been equipped with JENKINS VALVES

Century-old Hersey-Sparling Meter Company does everything possible to make good its slogan — You can't buy a better Water Meter than Hersey. One example is seen in a rule that any part of the meter not made by Hersey must be obtained from sources which have Hersey's own policy of making the Best. For valves, Hersey's standard for quality has been JENKINS for 35 years.

Hersey-Sparling's customers, like the buyers of any equipment that incorporates valves, see the famous Jenkins DIAMOND trade-mark on the valves as a sure sign that nothing has been spared in assuring reliability and low maintenance costs. Architects, engineers, contractors and operating men are bound to respect equipment that carries the valves they so often specify to assure trouble-free piping systems.

Of course, valves of less quality can be had for a little less money. But it is worth remembering that Jenkins Valves, so widely known for reliability, cost no more than any good valves. Jenkins Bros., 100 Park Ave., New York 17.

JENKINS VALVES



MOST TRUSTED TRADE-MARK IN THE VALVE WORLD



How General Electric's TRI SI CLAD motor gives you MORE THAN A MOTOR...

TRIPLE-PROTECTED TRI 55 CLAD MOTORS ARE BUILT TO TAKE IT!

General Electric Tri/Clad '55' motors are built to take it! Whatever your application requirements may be (long or short duty cycles . . . under ideal or adverse conditions . . . high or low temperatures) there's a Tri/Clad '55' motor to meet them.

The name "Tri/Clad" itself means "tripleprotected" against electrical failure, mechanical failure and physical damage.

ELECTRICAL PROTECTION-Mylar* insulation-Formex** wire insulation system throughout protects against electrical breakdown caused by effects of water, heat, or stresses.

MECHANICAL PROTECTION—Regreaseable ball bearings, long-lasting synthesized grease, and an oversize grease reservoir contribute to long bearing life, low maintenance.

PHYSICAL PROTECTION—Rugged cast-iron stator frame and endshields offer protection against corrosion, rust, or physical shock.

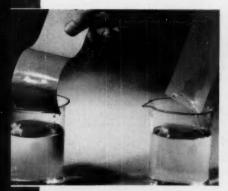
This extra ruggedness and durability found in General Electric Tri/Clad '55' motors—the ability to "take it"-pays off. It's your assurance that you're getting the best integral-hp motor that money can buy, a motor that will perform smoothly for years. It's General Electric's way of making your purchase truly more than a motor. Why not contact your local G-E Apparatus Sales Office? Or write Section 840-30, General Electric Co., Schenectady, New York.

Other "More Than A Motor" Benefits of G-E Tri/Clad '55' Motors: On-time Delivery • Expert Application Aid • Fast, Local Backup Service • Constant Design Innovation • Complete Line.

*Trademark of DuPont Co.

**Registered Trademark of General Electric Co.

GENERAL ELECTRIC



MYLAR slot and phase insulation assures long motor life, minimum maintenance. G-E motor insulation materials are non-hygroscopic.

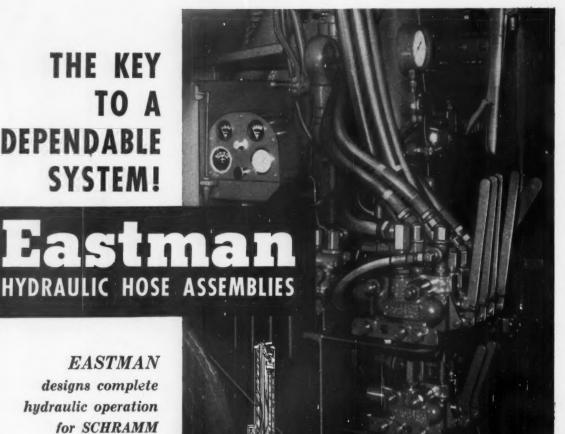


CAST-IRON FRAME and endshields provide rigidity; prevent motor from being twisted out of line. Integrally-cast ribbing along bottom adds extra strength to the motor. lengthens interval between regreasing.



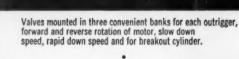
LONG-LIFE BEARING SYSTEM seals grease in, dirt out. Long-lasting grease in large reservoir increases bearing life,

THE KEY TO A DEPENDABLE SYSTEM!



EASTMAN designs complete hydraulic operation for SCHRAMM

Rotadrill



The cooperation of EASTMAN Engineering was enlisted in making the operation of this truck-mounted Schramm Rotadrill completely hydraulic.

Hydraulic power is delivered through EASTMAN Hydraulic Hose Assemblies to:

> 1. Three-Speed Reversible Rotation Head: Standard speeds-44, 65 and 120 r.p.m. with 26,500 inch pounds torque. 2. Cylinders controlling down feed, rapid feed and slow feed. 3. Controls for raising and lowering of mast. 4. Breakout Cylinder. 5. Hydraulic Winch and Hook. 6. Three Outriggers.

Dependable field service is assured through EASTMAN Two-Wire Braid High Pressure Hose with Permanently Attached Couplings providing a bond stronger than the hose itself.

Efficient power delivery through the extensive, multiple circuits of this rock-drilling rig is obtained through EASTMAN designed permanently attached hose assemblies which insure longer life and lower cost.



FOR ENGINEERS BY ENGINEERS

Let EASTMAN Engineering assist you in planning the initial layout of your hydraulic system—for most efficient power delivery and lowest cost.

MANUFACTURING COMPANY
Dept. MD-4. MANITOWOC, WISCONSIN



PERMANENTLY ATTACHED COUPLINGS for 1, 2, and 3 wire braid rubber cover hose



REUSABLE COUPLINGS



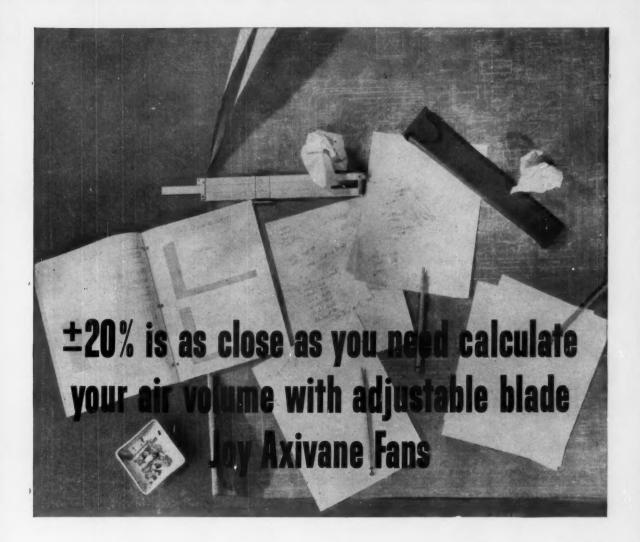
REUSABLE COUPLINGS



CLAMP COUPLINGS for 1, 2, and 3 wire braid rubber cover hose

Write today for Bulletin 100 and 200 on EASTMAN High, Medium and Low Pressure Hydraulic Hose Assemblies.







Ask for Bulletin 290-64B.

Computation of air volumes required for ventilation can be greatly simplified by installing Joy Axivane Fans. Standard models are furnished with adjustable blades which can be rotated to change pitch, and consequently volume, over a considerable range. This permits compensating for circumstances unforeseen when air requirements were computed, and also allows the installation of fans which will be able to efficiently supply additional air for pre-planned expansions of the plant. Blade adjustments can be made by anyone in a matter of minutes. Calibrated scales on hub and blades assure accurate matching of blade pitches.

Joy Axivane Fans are designed with integral motors to permit in-duct installation. This reduces installation costs, and saves space. The fans are available in a wide range of sizes for every type of duty, and can be furnished in special materials for use in corrosive atmospheres.

Whatever your fan requirements may be, Joy has the answer.



AIR MOVING EQUIPMENT FOR ALL INDUSTRY









JOY

Joy Manufacturing Company Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

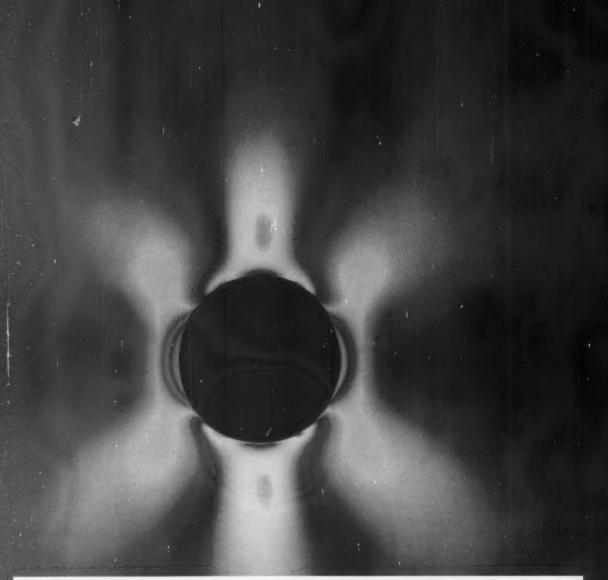


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

For Greatest Strength Per Dollar... Use (Malleable

To improve quality and cut costs, you'll find nothing better than Malleable iron castings. They provide more strength per dollar than any other metal, ferrous or non-ferrous! With Malleable you also get proven toughness, uniform quality and unsurpassed machinability.

See for yourself how much Malleable castings will improve your products and cut your costs. Send drawings or an outline of your requirements to a nearby Malleable castings producer who displays this symbol-

MEMBER

ASTINGS COUNC

For detailed information on "Strength Characteristics of Malleable Iron Castings", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

"Value Analysis" Proves-

Malleable Castings Improve Quality, Reduce Costs

When "Value Analysis" is your task, consider these outstanding advantages of Malleable iron castings: more strength per dollar than any other metal, ferrous or non-ferrous; exceptional machinability; metal exactly and only where it is needed; job-proven toughness.

Wide Range of Desirable Properties Available in Malleable Standard and pearlitic Malleable irons are available with strengths ranging from 50,000 p.s.i. to 120,000 p.s.i. tensile.

Note in this table the high ratio of yield strengths to tensile strengths — especially important to you because yield strength is generally the measure of useable strength.

TENSILE PROPERTIES-A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.
Standard 35018	53,000	35,000
32510	50,000	32,500
Pearlitic 45010	65,000	45,000
45007	68,000	45,000
48004	70,000	48,000
50007	75,000	50,000
53004	80,000	53,000
60003	80,000	60,000
80002	100,000	80,000

Yield as a Percent of Tensile		
	66	
	65	
	69	
	66	
	69	
	67	
13	66	
	75	
	80	

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties

Modulus of Elasticity in Tension, p.s.i. Ratio of Fatigue Strength to Tensile Strength Shear Strength - % of Tensile Strength **Torsional Strength** Compressive Strength, p.s.i.

Standard	Pearlitic	
25,000,000	26,000,000 28,000,000	
0.54	0.40 — 0.50	
80-90%	70 — 85%	
Approximatel	y equal to Tensile Strength	
200,000	250,000	

Switch to Malleable Saves 47% on Railroad Car Thrust Collar One of countless examples of cost reduction obtained by changing from other materials or processes to Malleable castings is this thrust collar used on railroad maintenance cars. While the steel part formerly used performed satisfactorily, it cost 99¢ before machining.

The cost of the standard Malleable casting before machining is only 51.7¢ — a saving of 47.3¢! Added to this, four machining operations - drilling of bolt hole, spot facing for bolt head and nut, milling the sleeve slot and sawing the transverse slot - were eliminated by switching to a casting. All remaining machining operations are improved due to Malleable's exceptional machinability.



Former part before machining (99¢)

Malleable casting before machining (51.7€)



Cost-Saving Engineering Assistance Available

The kind of engineering assistance that cut costs and improved product quality for these companies and thousands of others is available to you from any of the progressive producers of Malleable castings that are members of the Malleable Castings Council. Start increasing your product profitability right now - contact any of the companies listed below.

Free Information Folder

Your copy of an informative folder, Data Unit 110-Malleable Castings in the Value Analysis Spotlight, is available free from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, or from any member company.



For Quality and Economy...Use

For Service In Your Area Contact...

CONNECTICUT

Connecticut Mall. Castings Co., New Haven 6 Eastern Malleable Iron Co., Naugatuck New Haven Malleable Iron Co., New Haven 4

Eastern Malleable Iron Co., Wilmington 99

Central Fdry. Div., Gen. Motors, Danville Chicago Malleable Castings Co., Chicago 43 Moline Malleable Iron Co., St. Charles National Mall. and Steel Castings Co., Cicero 50 Peoria Malleable Castings Co., Peoria 1 Wagner Castings Company, Decatur

Albion Malleable Iron Company, Muncie Division, Muncie Link-Belt Company, Indianapolis 6 National Mall. & Steel Castings Co., Indianapolis 22

lowa Malleable Iron Co., Fairfield

MASSACHUSETTS

Beicher Malleable Iron Co., Easton MICHIGAN

Albion Malleable Iron Co., Albion Auto Specialties Mfg. Co., Saint Joseph Cadillac Malleable Iron Co., Cadillac Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA Northern Malleable Iron Co., St. Paul 6 MISSISSIPPI

Mississippi Malleable Iron Co., Meridian NEW HAMPSHIRE

Laconia Malleable Iron Co., Laconia

NEW YORK

Acme Steel & Mail. Iron Works, Bullato 7 Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay Oriskany Malleable Iron Co., Inc., Oriskany Westmoreland Mail. Iron Co., Westmoreland OHIO

American Malleable Castings Co., Marion Central Fdry. Div., Gen. Motors, Defiance Dayton Mall. Iron Co., Ironton Div., Ironton

MALLEAB

Dayton Mail. Iron Co., Ohio Mail. Div., Columbus 16 Maumee Malleable Castings Co., Toledo 5 National Mail. and Steel Castings Co., Cleveland 6

PENNSYLVANIA

PECNES TLYANGE, Philadelphia 22 Erie Malleable Iron Co., Erie Lancaster Malleable Castings Co., Lancaster Lehigh Foundries Company, Easton Meadville Malleable Iron Co., Meadville Pennsylvania Malleable Iron Corp., Lancaster

Texas Foundries, Inc., Lufkin

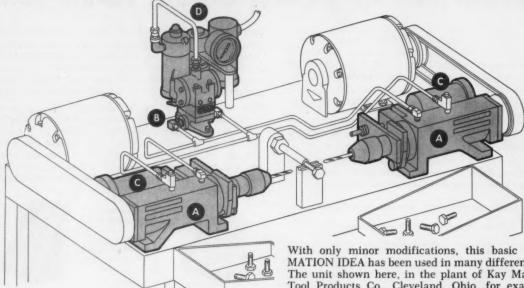
WEST VIRGINIA

West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN

WISCORDIN
Belle City Malieable Iron Co., Racine
Chain Bell Company, Milwaukee 1
Federal Malieable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malieable Castings Co., Racine
Milwaukee Malieable & Grey Iron Works, Milwaukee 45

YOUR OWN MEN CAN BUILD THIS PRECISION MACHINE FOR CUTTING COSTS IN DRILLING METALS, PLASTICS AND WOOD





As shown in the photo above and "keyed" in the drawing, this shop-built drilling machine consists essentially of two low-cost, air-operated Bellows-Locke Model 22A Drill Units (A), a Bellows Electroaire® operating control valve (B), two Bellows Hydro-Checks® which provide smooth precision operation (C) and a Bellows Lubri-Air® Control Unit which cleans, regulates and lubricates the air supply (D). Not visible is the foot-operated control pedal.

697-C

With only minor modifications, this basic SPOT-A-MATION IDEA has been used in many different plants. The unit shown here, in the plant of Kay Machine & Tool Products Co., Cleveland, Ohio, for example, is used to drill holes for cotter pins in aircraft bolts. The list of benefits belies its simplicity and low cost: production per man-hour is 66% better . . . tool life is greatly increased . . . rejects virtually eliminated . . and only a minimum of physical effort is required for what formerly was a very fatiguing operation.

The machine is built around two compact interlocked Bellows-Locke Model 22A Drill Units — air operated, hydraulically controlled — mounted horizontally in opposed positions. Automatic feeding, positioning and ejection could be incorporated easily by the addition of other Bellows "Controlled-Air-Power" Devices. This SPOT-A-MATION IDEA can be readily adapted to perform a wide range of other operations, such as punching, forming, riveting, crimping, etc., by using such other Bellows work units as The Bellows Air Motor® in place of the Drill units.

This machine is typical of the ways cost-conscious men the world over are using Bellows "Controlled-Air-Power" Devices to secure faster, better, lower-cost production. Opportunities exist in your plant, too. Why not investigate — today!

THIS "SPOT-A-MATION
IDEA" FILE IS
YOURS ON
REQUEST

Contains installation data, wiring diagrams and equipment lists for the "Spot-A-Mation" idea sketched above, as well as for scores of similar ideas you can use. Write Dept. MD-460, The Bellows Co., Akron 9, Ohio.

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

AKRON 9, OHIO

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio



Alcoa puts the metal where you want it

How BIG an impact have you seen lately? Alcoa can now make them up to 12 in, in diameter and 60 in, long.

When Alcoa's new 2,500-ton press hits an aluminum alloy slug, a giant impact is formed with the combined strength of an extrusion and forging.

Like their small brothers, these big new impacts can save you money. They are produced in one fast operation. There's no parting line to be ground. No scale to be removed. No draft to be cut off. Impacts have forged bases and extruded sections. Multiple parts can often be combined into one integral impact eliminating welded or mechanical joints. Machining is reduced, and excessive material waste is eliminated. You can get these big new Alcoa® Impacts in many alloys with tensile strengths up to 75,000 psi. Also made from aluminum powder metallurgy alloys which provide excellent properties at elevated temperatures.

Alcoa Impacts are unfailingly sound. They have smooth, corrosion-resistant surfaces. You can have them in plain or complex shapes with design features combining those of forgings and extru-

sions—flanges, steps, multiple walls, bosses, ribs.

In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where you want it. A call to Alcoa can mean ingenious design solutions. Start now; write for *Metal in Motion*, Alcoa's new 34-page brochure on impacts. Aluminum Company of America, 905-D Alcoa Building, Pittsburgh 19, Pa.



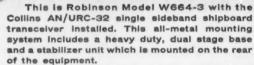
Alcoa puts the metal where you want it ... in impacts, castings, forgings, extrusions and screw machine parts.

ROBINSON Vibration and Shock Control

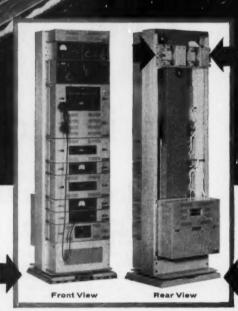
PROTECTS PERFORMANCE and assures
RELIABILITY in Shipboard Installations ...

Robinson has pioneered in the development and production of all-metal, low frequency vibration and shock mounting systems for the Navy's latest communications, radar, sonar and electronic computing equipment.

These are the first all-metal environmental control systems to be accepted by the Navy, and many are already in service aboard the latest missile cruisers, destroyers, aircraft carriers and nuclear submarines throughout the fleet.



Exclusive dual stage concept and highly damped MET-L-FLEX® resilient cushions assure the full range of vibration isolation and shock attenuation—double protection for extra reliability! Send for FREE brochures.



VIBRATION CONTROL IS RELIABILITY CONTROL

ROBINSON Technical Products Inc

TETERBORO N. J

Formerly ROBINSON AVIATION INC. . West Coast Engineering Office: Santa Monica, Calif.

DESIGNERS AND MANUFACTURERS OF VIBRATION CONTROL SYSTEMS

Circle 462 on Page 19

WHATEVER YOUR NEEDS.



Heres Industrys MOST COMPLETE

LINE OF QUALITY V-



V-BELTS

DA 358 V-BELTS



For highly compact, plus-power drives. First major design change in Multiple V-Belts in the last 30 years.



DA POSITIVE DRIVE BELTS Combines the advantages of the chain and gear with all of the advantages of the belt. No stretch, no metal to metal contact, no constant lubrication.

STURDY-LINK

Pre-stretched link belting available in regular, oil-resistant and staticconductive types.



GENERAL DUTY V-BELTS

Power-balanced construction for flexibility, durability and strength.



STEEL CABLE V-BELTS

Steel cable permits no-stretch installation. All belts are fluoroscoped to assure extra high quality.



RAILROAD BELTING



High tensile strength, low stretch belting features high fastener tear-out resistance.



DOUBLE V-BELTS

Relieved cross section assures maximum flex resistance. New control methods provide uniform cord section.

OPEN END V-BELTING



Used on drives where endless V-Belts are not practical. High fastener tear-out resistance.

RED SHIELD MULTIPLE V-BELTS

Red Shield Belts now offer 40 per cent extra capacity. Iso Dynamic matching and cord stability assure precise balance and long belt life. Also available in oil and heat resistant and static dissipating constructions.



VARIABLE SPEED BELTS



Abrasion resistant cover assures maximum life. Crowned cross section maintains stability under extreme loads.

Test . . . Compare . . . You'll Select

DURKEE-ATWOOD V-BELTS DURKEE-ATWOOD COMPANY • MINNEAPOLIS 13, MINNESOTA

Look for the DA



on your V-Belts

NEW center-neutral "Plug-in Limit" switch has 2 basic switches



Now you can control up to four isolated circuits in one limit switch. This new member of the MICRO SWITCH "Plug-in Limit" switch family actually performs the work of two double-break, snap-action limit switches, is designed for equipment that has parts moving in two directions.

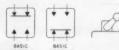
The adjustable actuating arm operates one basic switch when moved to the left, another when moved to the right. Neither switch is operated in the center position.

Write for Data Sheet 168 on the versatile "Center-Neutral" limit switch or call the nearby MICRO SWITCH branch office or authorized distributor listed in the Yellow Pages.

BASIC SWITCH CIRCUITS AS ACTUATOR CHANGES POSITION







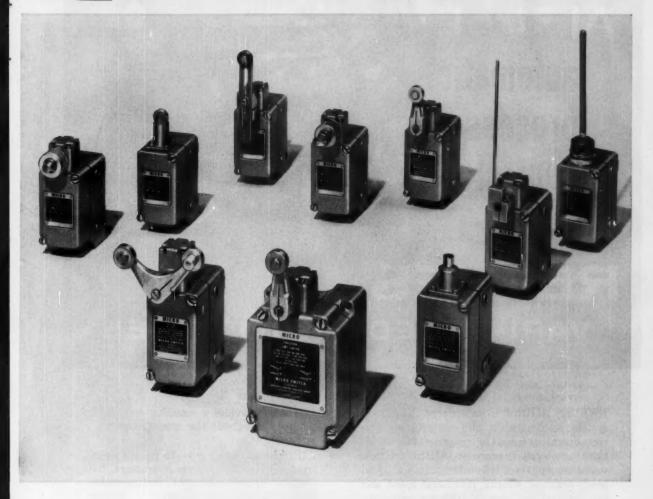
*Trademark



PLUG-IN DESIGN saves downtime because replacement takes less than a minute. It saves money because the receptacle remains in place and you do not have to replace the entire switch.

OILTIGHT SEALS on actuator shaft, between head and body, and on the receptacle rim, protect against oil splash or submersion. Operating head mounts in four positions.





MICRO SWITCH-the most complete line of "Plug-in Limit" switches

NOW TEN DIFFERENT MODELS in the line of "Plug-in Limit" switches built by MICRO SWITCH give you the widest choice in the industry. The flexibility in mounting arrangements and the variety of actuating systems make it possible to fit these time-saving units into most limit switch applications.

"Plug-in Limit" switches can be replaced in seconds by

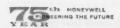
simply plugging them into the terminal enclosure like a radio tube. Special seals give these switches the best possible protection from oil, water and dust.

Write or call the MICRO SWITCH branch office or authorized distributor for information on the "200LS" Series. Ask MICRO SWITCH engineers to help you apply these costsaving "plug-ins" to your limit switch applications.

MICRO SWITCH . . . FREEPORT, ILLINOIS

A division of Honeywell

In Canada: Honeywell Controls Limited, Toronto 17, Ontario





Honeywell **MICRO SWITCH Precision Switches**

Circle 464 on Page 19



REEVES AIRtrol, in an open or closed loop system, automatically and continuously corrects operating speeds to compensate for variations in materials or processes. AIRtrol controls variable output speeds from temperature, liquid level, pressure, weight, peripheral speed and proportional flow signals. Here are important reasons why REEVES AIRtrol on REEVES Vari-Speed Motodrives, are performing efficiently on conveyors, pumps and machine tools . . . and in process industries handling solids and liquids.

 Exclusive contoured cam design results in output speed in direct proportion to instrument air signal. This permits linear (straight line) output speed over the entire output speed range of the drive.

- Cam also provides a sensitive and stable control throughout the speed range . . . automatically.
- AIRtrol operates on a 3—15 psi. air signal from any standard process-instrument. Exclusive "Span Adjustment" feature makes it possible to use the full signal . . . locking the 3 psi. signal to minimum speed and 15 psi. to maximum speed of the motodrive. This applies to units of 2:1 speed range, as well as 10:1.
- REEVES AIRtrol is available on all REEVES Vari-Speed Motodrives—¼ hp. through 40 hp., 2:1 through 10:1 speed range, with variable output speeds as high as 4660 to as low as 1.71 rpm.

For complete information on REEVES AIRtrol, call your nearest Reliance Sales Engineer.

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 284A1, CLEVELAND 17, OHIO Canadian Division: Toronto, Ontario Sales Offices and Distributors in Principal Cities



Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V*S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

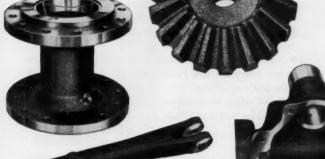
if cost reduction
is your problem

Value

analysis









To make or buy — to cast, forge or fabricate — that is often the question.

Before you decide, look into the advantages of National HTM (pearlitic malleable) castings over other methods of forming.

Among the great advantages of National HTM castings are closer as-cast tolerances that often eliminate machining operations ... excellent response to subsequent hardening operations, either induction or flame ... easy machinability on your present equipment ... high ultimate strength ... excellent non-seizing bearing qualities ... air or liquid quenching ... ability to be smooth-finished.

Yes, Value Analysis often makes the use of National HTM castings a must. And remember National HTM castings can be precision cast by the shell mold, CO₂ or green sand methods. Production costs tumble... performance and salability of your product spurt — with National HTM (pearlitic malleable) castings.

AA-9068

NATIONAL MALLEABLE CASTINGS COMPANY

Established 1868

Cleveland 6, Ohio

The nation's largest independent producer of malleable and pearlitic malleable

MEMBER

MALLEABLE

Circle 466 on Page 19

Important Physical Properties			
Brinell	163 to 302*		
Yield, psi	48,000 to 85,000*		
Ultimate, psi	70,000 to 110,000*		
Elongation, %	7 to 2*		

*Depending upon grade

SPICER TRACTION MOTOR DRIVES

...New Way To Solve **Old Power** Problems!

4,000 ft/lbs

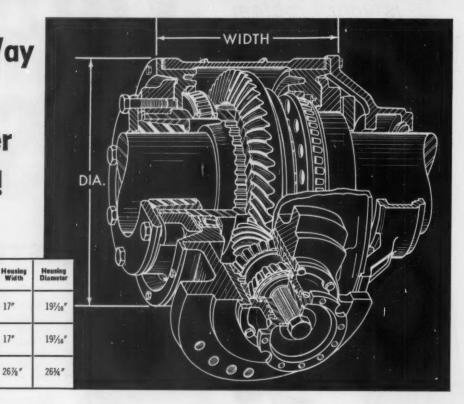
4,000 ft/lbs

7,500 ft/lbs

Model 7-5

Model 7-6

Model 8



Spicer Traction Motor Drives, long preferred by railroads the world over, can be adapted to a multitude of industrial and automotive uses ranging from fork lift trucks to giant earth-moving equipment.

17"

17"

26%"

The Spicer Model 7-6 drive illustrated above is similar to the Model 7-5 except that it has been designed to bolt directly to the driving motor through a gear coupling, thus eliminating the propeller shaft.

Both the Model 7-5 and the Model 8 Traction Motor Drives are designed for use with a separate driving motor. Each is coupled by a high-speed, heavy-duty Spicer tubular propeller shaft, dynamically balanced for high speed operation. Universal joints and slip splines are sealed to retain the lubricant and keep out foreign matter.

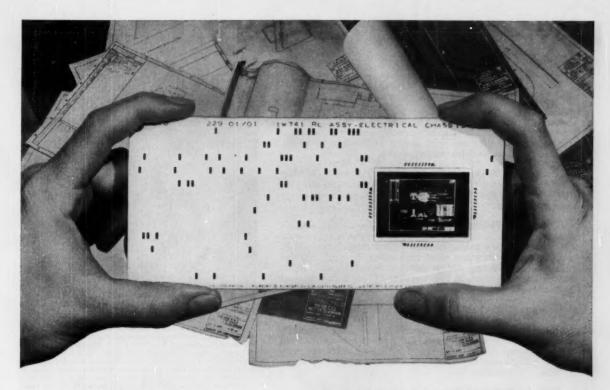
Spicer Traction Motor Drives have these outstanding design features:

- Customized Gearing—all Spicer traction drive units are assembled with matched ring and pinion-based on best tooth combination. You get quieter operation, longer gear
- Slip-Free Drive-lifetime positive drive is assured by driving through a splined quill and axle collar.
- Factory-Sealed—all drive units are completely sealed and tested against oil leaks before shipping.
- No Field Adjustments Needed-units are delivered completely assembled and factory-adjusted for bearing alignment and gear setting.
- Full Cushion Mounting—drive units are rubber mounted to minimize backlash, protect drive unit from vibration and shock loads.

For information on how you can fit Spicer Traction Motor Drives into your design plans, ask for your copy of the latest Spicer Technical Bulletin. And ask the Dana engineer for help with your specific problems.



SERVING TRANSPORTATION — Transmissions • Auxiliaries Universal Joints • Clutches • Propeller Shafts • Power Take-Offs Torque Converters . Axles . Powr-Lok Differentials . Gear Toledo 1, Ohio Boxes . Forgings . Stampings . Frames . Railway Drives



All the accuracy of original drawings but none of the "headaches"

New RECORDAK Precision Drawing System reproduces your drawings as needle-sharp images with remarkably uniform backgrounds on low-cost 35mm RECORDAK microfilm.

Mounting these frames in Filmsort aperture cards provides an active drawing file that speeds reference,

cuts printmaking costs, ends drawing wear-and-tear.

With decks of cards instead of bulky drawing files, you'll save time every time you refer to drawings, and when you need prints. Drawings can be kept at the finger tips instead of "far away"—instantly available for viewing in a Recordak film reader.

This greatly reduces need for reference blueprints. And it makes reference, itself, so much easier. For your microfilmed drawings stay clean and sharp—no smudging or loss of detail from handling or printmaking.

Easy to get paper prints and duplicate film copies

When, for any reason, you do want paper copies, reduced-size prints can be made fast—directly from the microfilm aperture card—by low-cost photographic, xerographic or electrostatic methods. Duplicate "microfilm cards" also can be made for branches, vendors, government agencies for pennies apiece.

Free booklet gives additional facts on this Recordak system available through Recordak and its nation-wide dealer organization.



TRECORDAK

(Subsidiary of Eastman Kodak Company)

originator of modern microfilming

—now in its 32nd year

IN CANADA contact Recordak of Canada Ltd., Toronto

mAI	L COUPON I	DDA!
RECORDAK COI 415 Madison Ave.,		DD-4
		ibing new RECORDAK bligation whatsoever.
Name		
Company		
Position		
Address		
City	Zone	State

VICKERS ECM COOLING SYSTEM plus

3M's FC-75 dissipates 47 kw input in 74 lb package

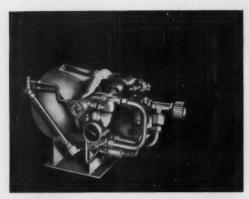
Vickers' 38 years of specializing in handling of fluids has been directed to "application-tailored" airborne cooling systems . . . reliable systems that are light weight and feature a broad range of flow and pressure characteristics.

This typical Vickers system circulates Minnesota Mining and Manufacturing Co.'s heat dissipating dielectric coolant, FC-75, through Sperry's advanced design electronic countermeasures system.

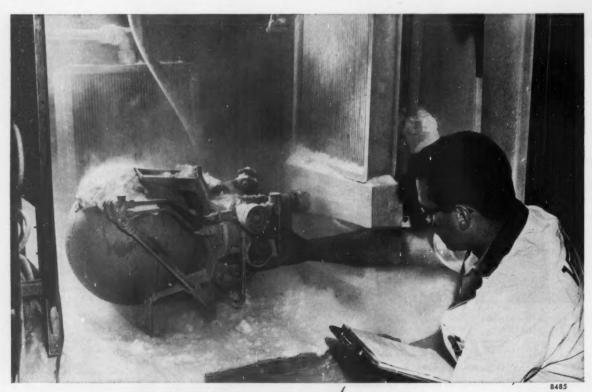
Heart of the Vickers cooling system is a single-stage, centrifugal pump that generates relatively low pressure and moves fluids at high flow rates. Because it is inherently simple in design, the Vickers pump offers high reliability and simplifies maintenance. Bearing design permits operation with fluids having low viscosities, in this instance FC-75, a fluordinated hydrocarbon.

Included in this package are safety interlocking devices for the protection of the pumping unit and ECM system. Maximum operating efficiency is assured even under unusually severe operating requirements. Such assurance stems from Vickers proven skills developed by long experience in designing and building components and systems for handling all types of fluid.

Write for Bulletin A-5244 for more details.

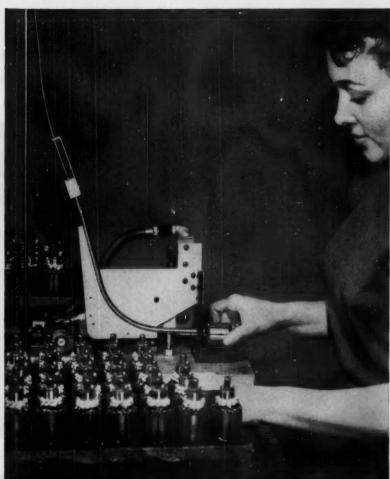


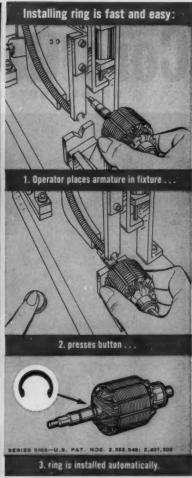
PUMPING UNIT AND CORE. Large airborne cooling system developed by Vickers' Aero Hydraulic Products division makes efficient use of 3M's FC-75 dielectric coolant to dissipate heat from electronic countermeasures equipment. Output pressure is required to be approximately 100 psi with fluid flow rates as high as 52 gpm. Operating range is from —65°F to 210°F. Pumping unit weighs 54 lb. dry and the heat exchanger core only an additional 20 lb. Shown below is part of the extensive testing program conducted by Vickers to prove out the new design. It included extremes of heat and cold as well as vibration, shock, attitude and other physical tests.



VICKERS INCORPORATED
DETROIT 32, MICHIGAN

division of
SPERRY RAND CORPORATION





Mechanized Truarc ring installation speeds assembly

eliminates costly shimming and gauging operations

Fast, semi-automatic assembly and the elimination of costly production operations are among the benefits Leece-Neville Co., Cleveland, Ohio, derives from the use of Truarc retaining rings in the manufacture of its fractional horsepower automotive motors.

Radially-assembled Truarc Series 5103 Crescent® rings—supplied pre-stacked—are used to position and lock the armature in the motor housing. Using the special Truarc pneumatic applicator-dispenser illustrated above, the operator merely inserts the rotor and presses a release button. The ring is installed automatically in a pre-cut groove on the rotor shaft!

The precision manufactured Truarc rings, seated in accurately located grooves, reduce accumulated tolerances from a possible maximum of .184" to .025". Costly, time-consuming shimming operations previously necessary to take up end play are eliminated, together with as many as four gauging operations required to select and place the shims.

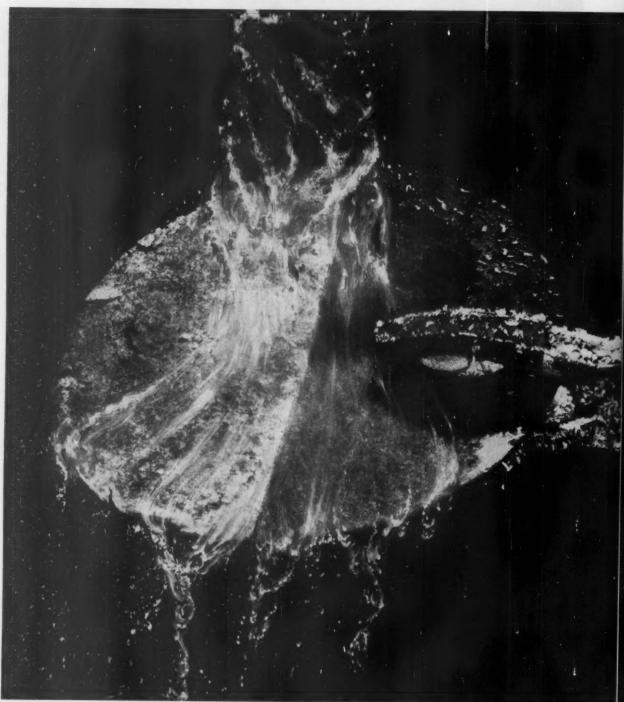
The Leece-Neville story is just one example of the way Truarc retaining rings are stepping up production on today's fast-moving assembly lines. These versatile fastening devices simplify design, speed assembly and eliminate rejects. In replacing conventional fasteners, they often improve product performance and reliability. All of these advantages are in addition to substantial cost savings!

Truarc retaining rings come in 50 functionally different types... up to 97 different sizes within a type... 6 metal specifications and 13 finishes. Special Truarc hand, magazine and automatic applicators and grooving tools make production-line application easy on virtually every type of product. Make sure you have on file the new 16-page Truarc assembly-tool catalog No. AT 10-58. Write for your copy today. And remember Waldes Truarc engineers are always ready to assist you with your special production problems. Write: Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, New York.



TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS @1939 WALDES KOHINOOR, INC.

Coro-Gard 1706 withstands



METAL coated with Coro-Gard 1706, right side, shows no effect from salt spray attack. Corroded left side is untreated.

2000-hour corrosion attack

Real corrosion resistance!—That's what you get when you specify new CORO-GARD 1706 Brand Protective Coating.

Specify CORO-GARD 1706 Coating for steel, aluminum, wood, concrete, cloth, even some plastics—wherever corrosion or abrasion must be fought. It provides maximum protection at low cost, brushes on as easily as paint. Self-priming, it goes on vertical surfaces with minimum sagging, provides unusually high coverage for economical use.

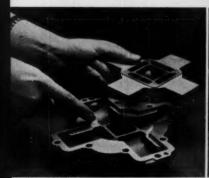
This neoprene rubber based coating air-cures to a tough, rubbery, protective film with exceptional

resistance to corrosive fluids and fumes, water and abrasion. It successfully resisted a 2000-hour salt spray attack, a 20-week submersion in 20% solution of hydrochloric acid, and a six-month weather exposure in Miami, Florida. After all this, CORO-GARD 1706 Coating still maintained its exceptional adhesion and flexibility, its corrosion and abrasion resistance.

See how CORO-GARD 1706 Coating can help you. For complete information, write today on your company letterhead, specifying area of interest, to: AC&S Division, 3M, Dept. SBR-40, St. Paul 6, Minn.

"CORD-GARD" is a Reg. T.M. of 3M Co.

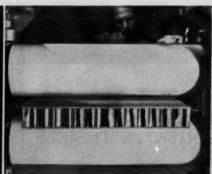
News about other 3M products



SIMPLETED PRODUCTION. 3M Adhesive EC-1386 bonds sections of hollow castings. This simplified method of producing complex castings eliminates high rejection rate of sand molding, costly machining, equipment required for mechanical fastening. The adhesive bond fills voids, cures quickly, can be machined for final touch-up.



SURE WAY TO SEAL. 3M Heat Expandable Sealers expand up to 125% under the normal heat of a paint-baking cycle, cure to a tough, flexible mass that keeps out dirt, water and weather, completely seal even the most irregular gap or seam. The unexpanded solid is also efficient as a gasket replacement sealer, flange sealer, and for other sealing jobs.



COLD SANDWICH BONDING. 3M Adhesive EC-1357 makes it possible to bond sandwich panels with a nip roller or cold press. You need no clamps or heated presses to complete tough core-to-skin bonds that resist moisture and high and low temperatures. This one adhesive bonds a variety of materials quickly, economically. Because of its dark color, it absorbs infrared heat quickly, dries fast.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY
... WHERE RESEARCH IS THE KEY TO TOMORROW





Fafnir's new "seal in a steel sandwich" stays put . . . resists push-in . . . improves protection!



- 1. Strong clamping action secures seal in bearing.
- 2. "Steel sandwich" provides rigid seal support, prevents push-in.
- 3 Tough, Buna-N rubber-impregnated fabric Plya-Seal offers "best protection yet" against contaminants, fumes, moisture.

Notice the steel supports on both sides of the seal in this Fafnir ball bearing. Notice, too, that the seal is held by clamping action from the rolled-in, firmly wedged supporting members.

This new Fafnir seal design is specifically engineered to prevent seal push-in, and to assure positive anchoring of the seal in the bearing. Protection against contaminants is increased...lubricant is more effectively locked in the bearing. Sealing

is further improved by the "baffle action" of the inner steel support, and the lip-in-groove design of the seal itself.

Fafnir ball bearings with new, "rolled-in," nonremovable Plya-Seals are now available in a wide range of sizes and in Fafnir power transmission units. Write for complete data. The Fafnir Bearing Company, New Britain, Conn.



Here's the inside story of industry's

MOST RUGGED HIGH VOLTAGE SWITCH

THIS SOLENOID AIR BREAK CONTACTOR IS THE HEART OF THE A-B STARTER LIVE

A tremendous operating life has been built into these new A-B high voltage, air break starters by using the same simple solenoid design—with only one moving part—that has proved good for millions of trouble free operations in Allen-Bradley low voltage starters. A-B high voltage starters are made for all types of service and for all types of motors up to 1500 hp, 2300 v: 2500 hp, 4600 v. Send for Publication 6080, today.



Faster Arc Suppression

New blowout design. Novel arc chutes are molded from an arc resistant material.



Double Break Contacts

Silver alloy contacts never need maintenance. Vertical motion assures uniform contact pressures.



Only One Moving Part

Simple solenoid design eliminates trouble-causing pins, pivots, and flexible jumpers.



A-B High Voltage Starter with Air Break Contactor

Bulletin 1159 high voltage air break, acrossthe-line induction motor starter in NEMA Type I enclosure. All Allen-Bradley high voltage starters are equipped with current limiting fuses with interrupting capacities of 150,000 kya at 2300 v; 250,000 kya at 4600 v. ALLEN-BRADLEY

Member of NEMA

Quality Motor Control

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

Some more special controls that are "standard" with Allen-Bradley!

Even Khrushchev couldn't claim a more complete line!



Phase Failure Phase Reversal Relays

The Bulletin 812 Style RF relay responds to all open phase conditions on a branch motor circuit and immediately removes the motor from the line. Also, the motor is disconnected when a phase reversal occurs anywhere in the system on the line side of the relay. "Fail safe" design.

Phase Failure, Style F covers f.l. currents from 1.5 to 300 amp in 4 sizes. Coils to 600 v, 60 cycles.

Phase Reversal, Style R made with coils for 110, 208/220, 440, 550 v for either 50 or 60 cycles.

Zero Speed Switch

Used for "plugging" duty, these switches prevent coasting and bring squirrel cage motors to a sudden stop. Also used to prevent application of reverse power before motor comes to a full stop. Adjustable operating speed.

Low Pressure Switch

Especially designed for domestic water pump service and commercial air compressor service. These inexpensive compact switches offer pressure ranges from 15 to 200 psi.



Bulletin 812 Style F



Bulletin 812 Style R



Bulletin 808



Bulletin 830

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.





Bulletin 805



Bulletin 836 Style T



Bulletin 837 Style A

Rotating Cam Limit Switches

Heavy-duty pilot controls used on rotating machines to initiate functions at any point of rotation. Made with up to 12 individually adjustable, independent circuits.

Foot Switches

Built for toughest service. Has maintenance free, snap-action contacts. Extended base prevents tipping. Made with hood (left), with top guard and without guard.

Pressure Controls

Oiltight enclosure for machine tool hydraulic systems operating at pressures up to 5000 psi. Operating pressure and differential are adjustable. Indicator shows trip point. Silver contacts never need service attention.

Temperature Controls

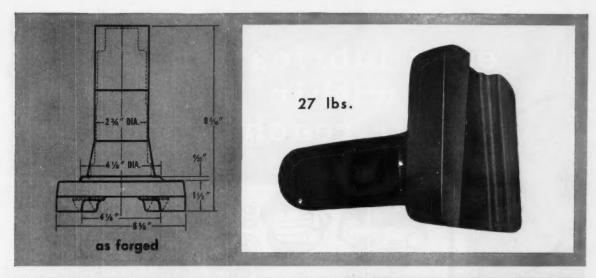
Newly designed bellows provides lower differentials. Rugged construction permits continuous cycling from zero to maximum setting. Vibration or mounting angle will not affect accuracy of operation. Temperature ranges from -150°F to 490°F.

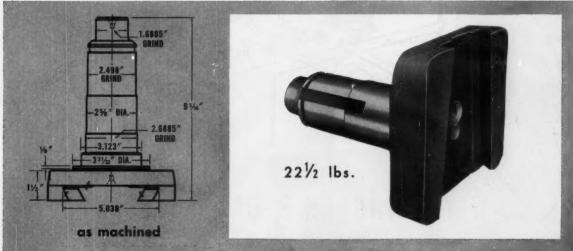
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY

Member of NEM

Quality Motor Control





New design idea cuts OEM part cost

COMMERCIAL upsets pedestal with offcenter shaft and dovetail groove—cuts machining time...saves metal.

Key part in new multi-purpose tractor is this steering link pedestal, designed for fast front-end changeover via its dovetailed groove.

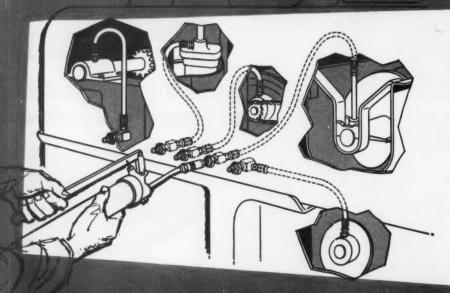
COMMERCIAL engineers working with the OEM proved that, despite the part's tricky dovetailed head and off-center shaft, it could be best produced as an upset forging. Precision manufacture on a 6" upsetter delivered the close tolerances necessary to save machining time and metal (forged weight 27 lbs.—machined weight 22½ lbs.). And, upset forging itself

created the dense, tough metal structure to guarantee high tensile, high torsional strength...light weight ...less machining rejects.

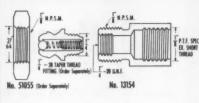
When you're looking for ways to cut your own metal working production costs, consider upset forging by COMMERCIAL—backed by over 30 years experience in the field. Address inquiries to Commercial Shearing & Stamping Company, Dept. S-18, Youngstown 1, Ohio.

COMMERCIAL shearing & stamping

easy lubrication is within your reach...



HITH LINCOLN'S BANK-LUBE SYSTEM





Proper lubrication of the machine you design is vital to its efficient operation and servicelife. If some of your grease fittings are necessarily obstructed by a shield or bulkhead, your customer probably won't give them the attention they require, unless you make it easy for him.

Lincoln makes this easy for you with its high-pressure Bank-Lube System, which brings those hard-to-reach lubrication points out of the "middle of the stream" to the bank. Straight nipple and 90° elbow fittings are available for bulkheads up to ½" thick. And Lincoln offers a complete selection of other components—adapters, connectors, and rubber, steel or Nylon feed lines.

The Bank-Lube System is simple to install, and permits even your smallest machine units to be included in a standardized lubricant application program at rock-bottom cost. For further details, write today for Design Engineers' Manual 92.

LINCOLN ENGINEERING COMPANY

Division of The McNeil Machine & Engineering Co. 4010 Goodfellow Blvd. • St. Louis 20, Mo.

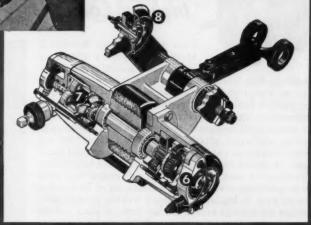
Add this "PUSH-PULL" POWER to your design

Anywhere you need "push-pull" power, design in a Gardner-Denver "Hoistractor"—small overhead cranes, conveyors and, of course, overhead hoists. This powerful, little prime mover rides any standard hoist beam ... moves loads to five tons. Consult your Gardner-Denver air tool specialist for details or write for Bulletin 87-1.

Check this design

- Neoprene drive wheel (6' dia.) gives 250-lb. drawbar pull against a beam for easy, high-speed moving of loads.
- 2 Drive-wheel load spring maintains constant drive regardless of irregularities in track.
- Sensitive air valves for smooth operation at all speeds from a slow creep to maximum. Controlled from remote position.
- Connecting drawbar furnished. Two types available.
- **5** Easily adjusted to meet standard beams in various widths by moving washers to outside plate.

- 6 Powerful, enclosed mechanical brake easily adjusted. Not dependent on air supply —applied automatically in the event air supply fails.
- Powered by axial-piston air motor. Pulls 2-ton load at 70 fpm. Easily rolls loads to five tons. Motor can't burn out.
- 8 Heavy, pressed steel wheels carburized and hardened for wear resistance. Deep flanges prevent wheels from climbing track. Ball bearings at all load points.

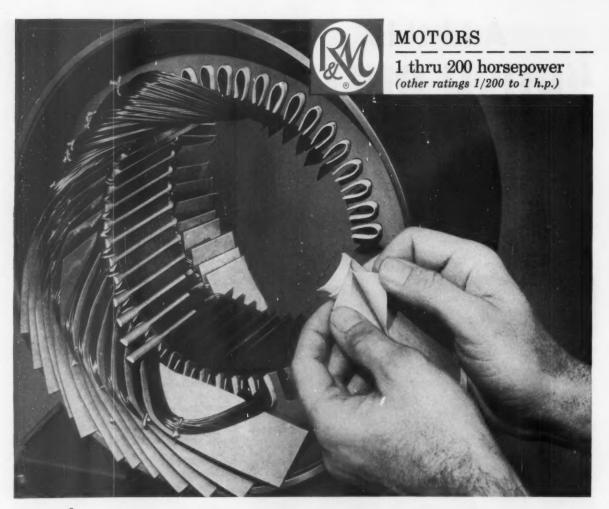




EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

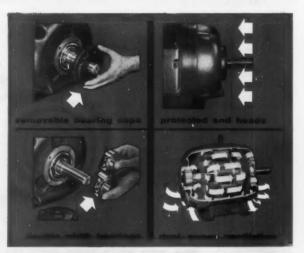


Locked-In, Laminated Insulation Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings.

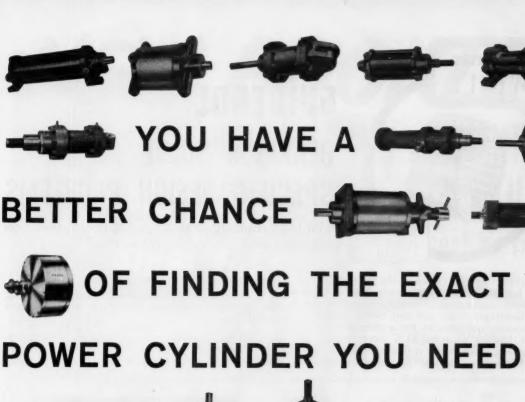
Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulaion you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 MD

* Pont registered trademark



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps
SPRINGFIELD, OHIO • BRANTFORD, ONTARIO









HERE'S WHY:

Anker-Holth makes the world's widest selection of standard power cylinders. That means that you have a better chance of finding the exact cylinder when you call on us for your power needs. Anker-Holth standard cylinders, built to JIC specifications with bores of 1 to 30 inches and strokes to 40 feet, are time-tested and experience-proved in every major industry. Nine complete lines are offered and all mountings are available.



Company.

This free catalog shows all our standard production models. Send for it today.

ANKER-HOLTH DIVISION THE WELLMAN ENGINEERING COMPANY 2723 CONNOR STREET. PORT HURON, MICH., U. S. A.

Send this

ANKER



HOLTH



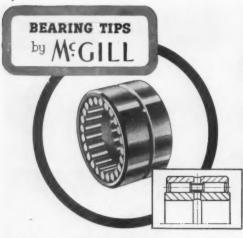
DIVISION, THE McDOWELL-WELLMAN COMPANIES

80A1-1

April 28, 1960

Circle 479 on Page 19

107



GUIDEROL° BEARINGS SOLVE SPECIFIC DESIGN PROBLEMS

with high capacity in small radial space, precision efficiency and "sealed in" lubrication

MCGILL GUIDEROL Bearings combine the higher inherent capacity of full complement needle roller bearings with "center-guided" roller control. GUIDEROL bearing construction encourages space and cost saving design of shaft and housing components. For a given shaft of 1" a GUIDEROL bearing provides 23% more capacity in 3%" less housing space than a typical cylindrical roller bearing. A comparable ball bearing uses almost an inch

larger on for 1500# less capacity.

Use the Sealed SGR series to protect GUIDEROL bearing efficiency when contamination exists. Avoid frequent re-lubrications.

GUIDEROL bearings are available with or without separable inner ring. Shaft sizes: \%" to 9\\4". Capacities to 128,670 lbs. (at 100 RPM).

Bucyrus-Erie Cuts Lubrication from Daily to Monthly with Sealed Guiderol Bearings

BUCYRUS-ERIE CO. has incorporated the advantages of GUIDEROL GR-28RSS, sealed bearings in their 11-B TRANSIT CRANE-EXCAVATOR. The bearings serve as mountings for sheaves in the 11-B boom suspension which is a wire rope system running from a powered cable drum over the sheaves. The GUIDEROL bearings decrease friction and provide a jerk-free lowering and raising of the boom. In addition, they have increased periods between lubrication from once a day to once a month under normal operation. BUCYRUS-ERIE also cites ease of assembly due to holding to close manufacturing tolerances as an additional benefit. Loads on these bearings are approximately 10,000 lbs.; speeds — 56 RPM. Bearings are used in both horizontal and vertical mountings.





Moline Tool Co. Get High Radial Load in Minimum Space

Each of the six spindles of the MOLINE Model 116U hydraulic rail feed, universal joint type drilling machine has two GUIDEROL upper bearings and two GUIDEROL lower bearings. The GUIDEROL bearings replaced bronze sleeve bearings used in previous design of the machine. The GUIDEROL bearings were selected for their ability to get the highest possible radial load in minimum space and still retain the advantages of a precision anti-friction bearing. Vertically mounted, the bearings are lubricated by drip feed oil from the upper drive unit. The unsealed GUIDEROL bearings with open ends permit a free flow and the roller retaining ring acts as an oil ring to pick up and distribute the lubricant.

Guiderol® Bearings Take Heavy Loads of High Volume Hydraulic Pump Service.

GALION ALLSTEEL BODY COMPANY'S combination high volume roller bearing pump and spool valve has been developed to furnish the large volume of high pressure oil needed for fast dumping with Duo-scopic hoists. These pumps operate the hydraulic cylinders on the complete line of Galion trailer dump bodies. Four small GUIDEROL

complete line of Galion trailer dump bodies. Four small GUIDEROL bearings easily accept loads of 3,500 pounds on the driving shaft and 4,500 pounds on the driven shaft. They provide maximum capacity in small radial space with a full complement of race width rollers. These center guided rollers help insure the precision performance required to increase pump capacity to 1,450 PSI at 1,000 RPM.



engineered electrical products



Send for Free Bearing Catalog No. 52A for complete Data.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA



This 36-page booklet newly published by Allegheny Ludlum is packed with technical data and authoritative information on both welded and seamless stainless steel tubing. There are more than 20 tables for ready reference and many photographs.

It will be helpful to design engineers and others interested in solving the many critical and demanding pipe and tubing applications. The booklet contains the best and latest information available on product and design data on the subject—the partial contents listed give some idea of its scope. You'll want a copy for your files.

Write for your free copy of Allegheny Stainless Steel Tubing, Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept. MD-4.

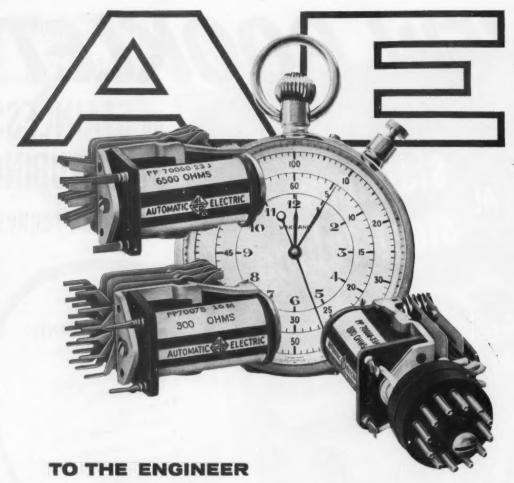
1287

ALLEGHENY LUDLUM

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT





looking for a quick connection

Engineers out to cut costs at no expense of reliability can count on dramatic savings in assembly and wiring time by designing around AE Class E relays with quick-connect terminals.

Series EQPC is designed for direct insertion into printed circuits. Series EQTT, with Taper-Tab terminals, provides firm, highconductivity connections without soldering.

AE also supplies Class E relays prewired for plug-in—with standard 8- to 20-prong octal plugs. Where additional relay protection is essential, the plug-in types are available in hermetically sealed containers or with dust-tight housings and hold-down brackets.

The AE Class E relay is a miniaturized version of the premium-quality Class B, with many of its best features. Perfect contact reliability exceeding 200 million operations is common.

AE is also equipped to supply wired and assembled, custom-built control units, or to help you develop complete systems.

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1702-E on *Relays for Industry*, and the new 32-page booklet on *Basic Circuits*.

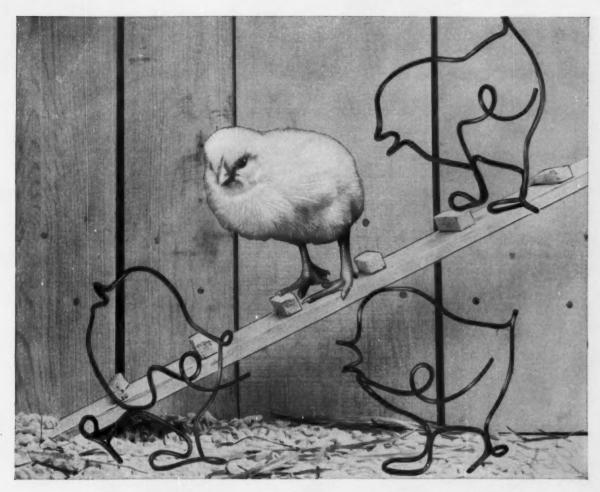




AUTOMATIC ELECTRIC



Subsidiary of
GENERAL TELEPHONE & ELECTRONICS



Bundy can mass-fabricate practically anything

Bundyweld®—the original double-walled steel tubing—is ideal for everything from simple bends to complex shapes

The old adage, "Don't count your chickens before they hatch," is a good one... but it rarely applies to Bundy. That's because, no matter how complex your tubing problem, you can count on Bundy for the perfect solution.

Bundy engineers and designers are backed by years of experience in the mass-fabrication of steel tubing. And they are available to you at any stage of product development for time- and money-saving suggestions. Their key: Bundyweld®!

Bundyweld steel tubing is double-walled, copper-brazed, stronger, with higher bursting and fatigue strengths. That makes Bundyweld the safety standard in small-diameter tubing—and a wise choice for a wide variety of tubing applications! Covered by Government Spec. MIL-T-3520, Type III.

So, when you want to talk tubing, talk to the leader—Bundy! Phone, write, or wire Bundy Tubing Company, Detroit 14, Michigan.







Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to %" O.D.

There's no substitute for the original Bundyweld Tubing.

BUNDY TUBING COMPANY

HOMETOWN, PA. . DETROIT 14, MICH. . WINCHESTER, KY.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

Franklin INST@VERSE Motors

ENCOURAGE PRODUCT DESIGN IMPROVEMENT



■ Standard INST-O-VERSE® Motors

Full-torque, instant-reversing motors available in 1-phase, 1725 RPM, 115 or 230 V., 1/6 H.P. through 1 H.P., sleeve or ball bearing types with NEMA standard or application-engineered mountings. Cost is less than 3-phase reversing motors.



Instant-reversing GEARMOTOR power units

Built to specifications with epicyclic, worm, bevel or other gears. Ratios to requirements. Automatic or manual controlled . . . on-off, forward-reverse operation of one or more output shafts.



■ GEAR-O-MATIC® power package for automation

Includes all functional benefits of any signal transducing system to energize stop-go, and instant-reversing of geared power unit. limit switches, automatic safety stop and indicator outlet are built into control box.



■ Special MULTI-SHAFT system

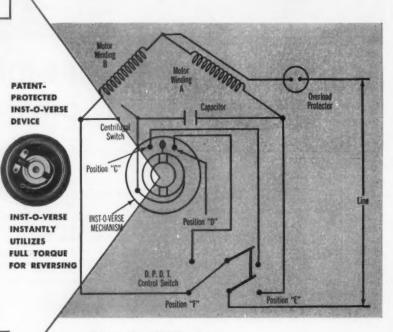
Franklineered to customer requirements, push-button controls monitor selective actions of 3 output shafts. Designed for dependable performance and long life for applications requiring high reliability.

Control switch in "E" position . . . rotation is clockwise. Inst-O-Verse makes contact in "D" position due to shaft rotation. Motor operates as capacitor start, induction run with "B" as start winding.

Instant reversal occurs when control switch is thrown to "F" position as the Inst-O-Verse device has provided a circuit, bypassing the open centrifugal switch.

Operates in either direction as capacitor-start motor or instantly reversing motor. Operation is independent of sequence of rotational operation.





Write for FACTS about:

- INST-O-VERSE MOTOR
- GEAR-O-MATIC MOTORS
- GEARMOTORS

MULTI-SHAFT SYSTEM

Franklin Electric Co., Inc. BLUFFTON, INDIANA



UNIFORMITY... casting after casting

Meehanite's exclusive manufacturing process gives you positive assurance of always getting clean, sound castings with uniform structure and properties in all sections . . . in every casting . . . in every group of castings. This ability to control quality and uniformity saves you time and money in your shop and results in dependable performance in service.

Avoid the risk of hidden defects which cause high machining costs and casting rejects. Don't take a chance on bargain prices or so-called "equivalents." Specify Meehanite metal and be sure of obtaining castings that do the job better.

There are 30 types of Meehanite metal—each made to its own structural constitution and possessing its own combination of engineering properties. Why not have a field engineer from a Meehanite foundry help you select the one type that will most completely meet your design and service requirements. Check the Meehanite foundries listed below for the one nearest you. You'll like doing business with a Meehanite foundry.

Write today for your free single copy of the Meehanite Wall Chart. It contains complete specifications on many types of Meehanite.

MEEHANITE METAL

The American Laundry Machinery Co., Rochester, N. Y. Atlas Foundry Co., Detroit, Mich.

Banner Iron Works, St. Louis, Mo. Barnett Foundry & Machine Co., Irvington, N. J.

Casting Service Corp., LaPorte, Indiana and Bridgman, Michigan

Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio Compton Foundry, Compton, Calif.

The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa. Crawford & Doherty Foundry Co.,

Portland, Ore.

Dayton Casting Co., Dayton, Ohio

Empire Foundry Co., Tulsa, Okla. Florence Pipe Foundry & Machine Co., Florence, N. J.

Fulton Foundry & Machines Co., Inc., Cleveland, Ohio

General Foundry & Mfg., Flint, Mich. Georgia Iron Works, Augusta, Ga.

Greenlee Foundries, Inc., Chicago, Ill.

Hamilton Foundry Inc., Hamilton, Ohio Hardinge Co., Inc., York, Pa.

Johnstone Foundries, Inc., Grave City, Pa. Kanawha Manufacturing Co.,

Charleston, W. Va. Kennedy Van Saun Mfg. & Eng. Corp.,

Danville, Pa. Lincoln Foundry Corp., Los Angeles, Calif. Oil City Iron Works, Corsicana, Texas Palmyra Foundry Co., Inc., Palmyra, N. J. The Henry Perkins Co., Bridgewater, Mass.

Pohlman Foundry Co., Inc., Buffalo, N. Y. Rosedale Foundry & Machine Co., Pittsburgh, Pa.

Ross-Meehan Foundries, Chattanooga, Tenn. Sonith Foundries of FMC, Indianapolis, Ind. Standard Foundry Co., Worcester, Mass.

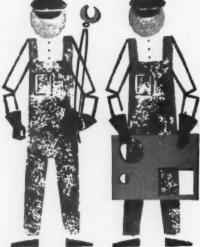
The Stearns-Roger Mfg. Co., Denver, Colo. Vulcan Foundry Co., Oakland, Calif.

Washington Iron Works, Seattle, Wash. Dorr-Oliver-Long, Ltd., Orillia, Ontario

Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario Otis Elevator Co., Ltd., Hamilton, Ontario

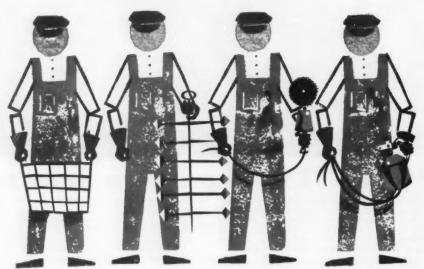
MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

ALL UNDER ONE ROOF AT BROWN-LIPE-CHAPIN



DIE CASTING

METAL STAMPING



ANODIZING

NEW DURA-PLATE ELECTROPLATING

POLISHING

PAINTING

Everything's done on virtually one continuous assembly line—from die casting or metal stamping to the gleaming finished part.

Every process is under one roof: Extensive facilities for precision die casting parts of any shape and sizes up to six feet in length . . . an array of presses for stamping parts of any metal . . . complete facilities for rolled sections . . . and efficient assembly line

processes for polishing, anodizing, painting and electroplating with new Dura-Plate.

Two plants, strategically located in Syracuse, New York and Elyria, Ohio, offer the same complete, under-one-roof facilities to speed delivery of your parts to meet your schedules right on time. So whatever your product, write or phone Brown-Lipe-Chapin, Syracuse, New York for prompt information.



RELIABILITY by BROWN · LIPE · CHAPIN

DIVISION OF GENERAL MOTORS CORROLATION



Metallurgical Memo from General Electric

1800°F

RENÉ 41*... THE SUPER ALLOY THAT WORKS WONDERS IN THE

HIGH TEMPERATURE BRACKET

1000° F

Tops in Strength . . . in Stability . . . in Increased Ductility . . . in Corrosion Resistance!

Properties of René 41*... the proved General Electric vacuum-induction-melted super alloy . . . demonstrate unique operational reliability.

Designed to meet severely stressed supersonic temperature applications, René 41 has worked wonders for many needs in the space age. High-strength characteristics and ease of workability make it one of the most versatile high-temperature materials available today.

René 41 is available in strip, sheet, bars, wire, and in forgings, plates or billets. It can be readily machined, forged, drawn, spun, welded or brazed.

If your problems center in the high-temperature range, write for all the facts on G-E high-purity vacuum-induction-melted alloys. Feel free to phone for the on-the-job assistance of a G-E engineer. Metallurgical Products Department of General Electric Companu, 11159 E. 8 Mile Street, Detroit 32, Michigan.

*René 41 is a trademark of the General Electric Company



Operator checks molten alloy in furnace beneath him where temperatures range from 2500° to 3000° F. Vacuum-induction melting makes René 41 or any composition virtually free from impurities and inclusions which reduce causes of premature structural failures.

METALLURGICAL PRODUCTS DEPARTMENT

GENERAL (ELECTRIC

CARBOLOY® CEMENTED CARBIDES . MAN-MADE DIAMONDS . MAGNETIC MATERIALS . THERMISTORS . THYRITE® . VACUUM-MELTED ALLOYS

Where there's a wheel there's a way...

with

custom engineered SHAFTS

In every wheel-and-shaft application, the extra toughness built into U.S. Shafts pays off in longer-lasting, trouble-free performance. U.S. Axle's modern manufacturing facilities, backed by 40 years of specialized know-how, will produce shafts to your most exacting specifications. Any size . . . any type . . . precision-made of finest alloy steels . . . strengthened by heat-treating and shot-peening processes. For maximum durability and efficiency in your product, plan around U.S. Custom-Engineered Shafts!

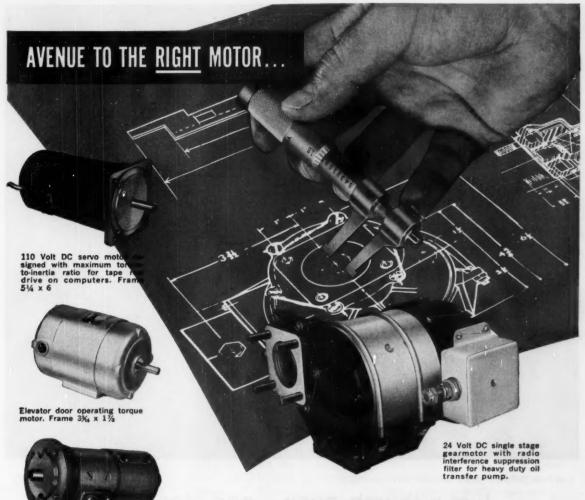
For prompt quotations, submit prints and specifications.

Send for FREE brochure on U.S. Axle — your best source for Custom-Engineered shafts

THE WORLD TURNS ON

THE US AXLE COMPANY, INC

Since 1920 . Pottstown, Pennsylvania



 $_{-}$, voic DC shunt wound aircraft motor qualified to specification MIL-M-8609A (ASG) for small high speed pumps. Frame $1\,\%$ x $1\,\%$



Heavy duty motor for industrial vacuum cleaners, colloid mills, hoists, etc. Frame 6 x 21/2

A design that meets your exact motor requirements

Into the design of a Lamb® motor goes our 45 years of specialized experience in powering aircraft components, industrial, commercial and domestic products.

Out of the design comes a motor having the dependability and smooth, efficient operation required for the exceptional performance of your product.

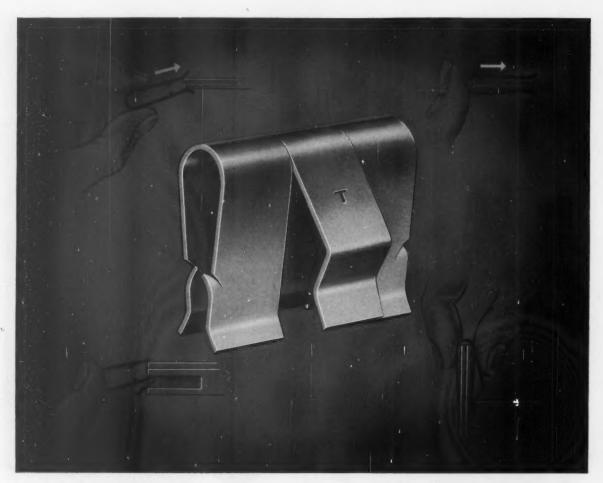
These advantages are standard with Lamb motors . . . engineered to your exact requirements . . . mass produced to obtain most favorable cost. Descriptive folder sent on request.

THE LAMB ELECTRIC COMPANY . KENT, OHIO

A Division of American Machine and Metals, Inc. sde: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

Lamb Electric SPECIAL APPLICATION MOTORS

Divisions of American Machine and Metals, Inc., New York 7, New York TROY LAUNDRY MACHINERY RIEHLE TESTING MACHINES • DEBOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC CO. • HUNTER SPRING CO. • GLASER-STEERS CORP.



Another SPEED NUT brand fastener...

Just a thumb-push...and steel teeth fasten steel with Tinnerman "U" CLIPS

Twin-action gives this Tinnerman "U" SPEED CLIP® extra holding power in fastening together two sheets of metal, plastic or wood without screws...the heat-treated spring steel tension in the "U" exerts a clamping action...the tiny upset barbs bite in and hold on for keeps.

Cost of assembly is substantially reduced when you use Tinnerman "U" Clips for fastening...extra assembly steps are eliminated... no special tools or skills are required... and Tinnerman "U" Clips hold for good!

Speed Nut Brand "U" Clips are easy to apply ... merely thumb-push them over the edges of the panels. A variety of Tinnerman fastener features can also be incorporated with the "U" Clip principle...cable clips, protruding legs to hold glass panels in lighting fixtures, and others.

Call your Tinnerman Speed Nut representative today . . . if he's not listed in your "Yellow Pages" Directory under "Fasteners", write direct.

TINNERMAN PRODUCTS, INC. Dept. 12 · P.O. Box 6688 · Cleveland 1, Ohlo



CAMADA: Dominion Fasturers Ltd., Hamilton, Ontario. CREAT DRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon do Rothschild, Suresses (Soine). GERMANY: Mecano-Dundy Smbill, Neighberg.

DESIGN

April 28, 1960



The Man Nobody Sees

THE big jet had just roared into the air from Orly Field. All at once a commotion at the rear of the cabin centered around a passenger in obvious physical distress. Anxious looks were exchanged. The question came over the speaker system: Is there a doctor aboard? An unassuming man rose and calmly made his way to the suffering man. Immediately the tension was relieved and passengers and crew settled down for the long flight to New York. The situation was under control.

Here was professional recognition in action. Wouldn't it be wonderful if the work of the engineer could have such an impact on the public mind?

What the public expects of a doctor is clear. For one thing, he is expected to cope with human emergencies. What emergencies within the experience of the general public can an engineer cope with? Fix a stalled automobile? Repair a TV set? Shouldn't a professional engineer be able to do for a piece of engineered equipment what a doctor can do for the human body? Silly question, of course, but not to a sizable segment of the general public.

On the other hand, engineers seem to be natural targets for unfavorable publicity. The mechanic who arrives to get the car started or revive the dead TV is likely to sound off on the shortcomings of the engineers who designed the equipment. And the satellite which, if successful, would be hailed as a great scientific achievement is deemed a dismal engineering failure if unsuccessful.

With public glorification of the scientist on the one hand, and the public's personal experience with the mechanic's work on the other, the engineer is stranded in the middle. He's the man nobody sees.

An important attribute of a profession is a body of knowledge not possessed by the general public. Why shouldn't the engineer take advantage of any opportunities to demonstrate his expert knowledge of his field?

The engineer could personally interpret modern developments in earthy terms for his lay friends and acquaintances when such subjects come up for discussion. It might help clarify a public "image" of the engineer as a knowledgeable person whose profession, no less than the doctor's, has an impact on all our daily lives.

bolin barmilael



Demands of today's color-conscious American public are easily met with gay hues of plastics. One of the principal virtues of plastics is the almost infinite freedom they extend in the choice of color.

But this freedom isn't "free"—design, molding methods, material quantities, and color-matching requirements all have a definite impact on . . .



The cost of

COLOR IN PLASTICS

SELECTION of color in plastics has a direct influence on several phases of manufacturing costs. An unwise color choice can have a significant and sometimes disastrous effect on the total cost of a finished product.

Modern production techniques have made the approach to color selection almost too nonchalant. All too frequently, colors are chosen after design and tooling are complete—even where both are influenced by the color decision.

A. J. BENJAMIN

Color Styling Service Plastics Div. Monsanto Chemical Co. Springfield, Mass.

2010202020202020202020202020202020

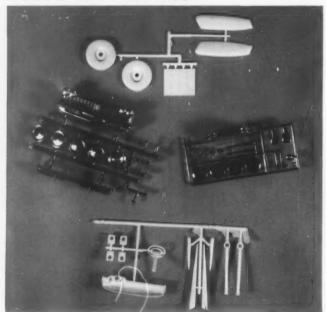


Fig. 1—Multipart tooling. Variety of parts for automobile model produced in one molding. Center parts have been vacuum-metallized after molding.

Molding Methods Versus Color Freedom

Recently, for example, a somewhat expensive household accessory was designed to be injection molded in several separate components. The design was such that the assembled article would be striking and attractive if one or two of these pieces were used as accents, in a color sharply contrasting with the principal mass. Without these accents, the object became uninteresting and utilitarian. However, when the problem was first brought to plastics technologists, many thousands of dollars had already been spent for tools. A considerable saving had been realized by making all these pieces in the same mold, so that all were produced in one operation from the same feed material and, of course, all in the same color.

Then came the request for the obvious, but not easy, solution: To select reversible colors which would be usable in either combination; first, with one as accent and the other as the main theme, then, with the two reversed. This was indeed the only course open without large expense, and a competent job was done on this basis. It would be surprising, however, if the public purchased two alternate color schemes in equal numbers merely because the machine produced them in exactly equal quantities.

The largest volume of plastics products is produced by molding. This may be compression molding, injection molding, or vacuum forming—all use a mold, together with heat and pressure. If several different small parts are involved, and if the design

permits their production in identical colors, they often are combined in one mold, Fig. 1. The resulting economy is not in tool cost alone, but also in machine time and labor. Most parts of hobby kits for construction of model aircraft, ships, and autos are made of styrene plastic in this way. Many small parts are combined into one molded piece and must be detached from a central sprue before assembling. This procedure reduces manufacturing cost by producing different parts of one color in one operation.

Balancing Material Requirements and Color Choice

Another area where color selection influences manufacturing costs is that of materials purchasing. Most plastics have a sliding scale of prices based on the quantity of material ordered in any one color. Since generally a color made especially for one application cannot be used for another, the volume must permit long, continuous runs, or manufacturing costs rise substantially.

Suppose that a molded barrel for a mechanical pencil weighs 0.05 oz. If it is to be made of styrene plastic, the minimum raw material price is obtained on a quantity of 20,000 lb, or enough to produce 6,400,000 pencils. Then, if the design calls for the barrel to be assembled from two moldings of equal size and contrasting colors, the minimum price can be obtained only on the same quantity of each color—enough material for 12,800,000 pencils. Moreover, it is not enough that the total anticipated sale of the item be sufficient to justify this volume of material, but also that its

forecasted monthly sale be large enough to permit material inventories of this magnitude.

If the total poundage simply will not support two colors, and monotone styling is most undesirable, it may be possible to reduce the bulk of accent parts considerably. In the pencils used as an example, the contrasting part could be reduced to a small cap. Then, although the price of that particular material may be quite high, not much of it is needed and the average material cost for the whole assembly may be practical.

With some materials, other solutions are possible. Some molded thermoplastics, notably styrene and polyethylene, can be colored as part of the molding operation. Here, the fabricator purchases clear or "natural" resin and produces a diversity of colored objects in any quantity required and without cost penalty on the material. This is the so-called "dry coloring" process.

Using the dry coloring process, the material for the pencil could be drawn from common stocks, used also for toy trucks or hobby kits. While in common use for toys, housewares, and similar articles, the process is not employed generally for components of expensive durables like refrigerators. Nor is it used where quality standards are extremely rigid, such as in plastic wall tile.

Matching Plastic and Nonplastic Parts

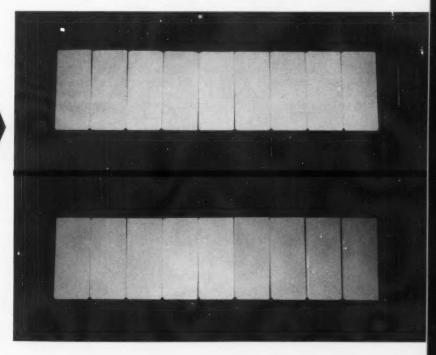
Apart from quantity-price relationships, color may have another direct effect on price. Most plastic materials carry the same price in a given quantity regardless of the exact color matched. This perhaps is not quite realistic, since all colorants are not equally expensive, but their influence on manufacturing cost is usually not large enough to justify complicating the price structure. However, plastics are often used in combination with matching or harmonizing parts of other materials such as metal, porcelain, and organic coatings—a different situation. Here, the formula costs of certain groups of colors are so much higher than others that the selling price of these groups has been increased.

The use of multipart tooling and the practice of color consolidation may solve some problems—but it can introduce others. Unless accounted for in product design, the increased number of parts of the "same" color can cause serious color-control difficulties

Some users of colored materials are not aware of all the ramifications of color control. If they purchase shaped parts, they will specify their dimensions, plus or minus so many thousandths. If they buy chemicals, they will state the allowable impurities in tenths or hundredths of a per cent. A similar universal system of tolerances unfortunately does not exist for specifying colored materials. Although colorimetry has developed several techniques for numerical statement of color differences, such as the National Bureau of Standards' units of color difference and Monsanto's Micro-match instrumental color control system, these are not widely understood or applied.

With any colored material, the plain fact is that successive batches of the same color are not exactly the same color. The difference may be small, commercially unimportant, but it is almost always there. Frequently, upon close inspection, it is quite perceptible.

Fig. 2—Do they match? The same panels arranged to minimize, then accentuate their color differences.



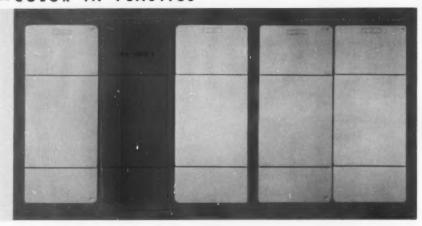


Fig. 3—Do they match? Panels shown at left are separated by a strip of trim. Same panels are shown, right, side by side.

The reason, as with so many quality-control standards, is a blend of technology and economics. Generally speaking, color formulas do not reproduce. A blend of colorants which produces a hundred thousand pounds, or gallons, or yards of material of uniform and acceptable color this month can theoretically be repeated a few weeks later. But even when compounded with the utmost care and exactitude, the blend can result in a product not even resembling the previous batch. The formula must be corrected for each production batch—seasoned to taste, as it were. This process of correction is neither automatic nor completely predictable. Often a number of tentative corrections must be tried.

Meanwhile, batch-process machines are shut down and continuous processes are belching forth unusable products. The proper color is being approached more closely every hour. How good is good enough? Insistence on a degree of fidelity beyond that required by the ultimate consumer will raise the manufacturing cost and price of the material to absurd extremes—even 1000 per cent.

Designing Adjacent Plastic Surfaces

It is a safe assumption that the product is usually accepted short of perfection, but occasionally an article is designed so that perfection itself would hardly suffice. If two pieces join with two surfaces in the same plane, forming an unrelieved continuous area, conditions for perceiving any minute color difference between the two are ideal, Fig. 2. The color differences are usually small enough so that any factor preventing perfect observation will mask them.

Separation of the matching parts by a short distance is, of course, ideal. A strip of trim separating two matching panels, Fig. 3, is almost equally effective. If no other expedient is available, simply placing them in different planes or at a slight angle to each other will make a small color difference pass without notice. Unless one of these devices is used, the manufacturer of the article may encounter serious difficulty.

Plastic components are usually molded at a dis-



All-plastic design of Sylvania TV receiver cabinet skillfully uses darkblue feature strip to separate paleblue surfaces.



Fig. 4 — Metamerism exaggerated. The only change between these two photos was the flick of a light switch.

tance from final assembly. Different parts for the same assembly are not always produced in the same plant, much less at the same time. Color match requirements should not be so stringent that they can be satisfied only by mating parts from the same batch. Such requirements are always inconvenient and often completely impractical.

How Lighting Affects Color Matching

There are more subtle factors influencing fidelity of color matching. To make two colors a true spectral match under any viewing conditions, they must be compounded from identical colorants. It is possible to use colorants basically different from those in a color sample and produce a match which will appear exact under any specific illumination. But change the light source under which the two are viewed and they no longer resemble each other. Such colors are termed a "metameric" match, Fig. 4.

The physical requirements to be met by colorants for different media are radically different. Most paints dry at atmospheric temperature. Plastics are heated to several hundred degrees when processed. Ceramics may be baked at several thousand degrees. Colored plastics may contain less than 1 per cent pigment. Colored paints will contain over 50 per cent.

These conditions make different choices of colorant absolutely mandatory, and metameric matches inevitable. Components matched in color in these different materials must not be assembled in a manner that requires absolute color fidelity. In fact, if the parts can be made in complementary or contrasting hues, the contrast should be definite. Otherwise the combined effects of lot-to-lot variation and illumination change may detract from the color harmony.

The effect of illumination on color can play some strange tricks. For instance, a rectangular box may be formed as an integral unit, of the same material and color throughout. Viewed with the light from certain angles, the inside may appear much darker and more saturated in hue than the outside, due to multiple reflections in the interior. If the box's

lid must appear to match the interior, the lid may have to be constructed of a darker material.

When To Use Special Colors

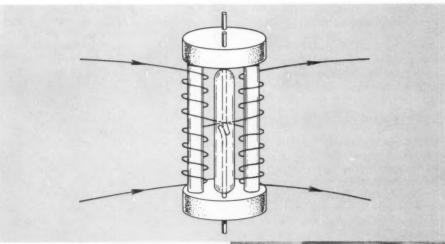
Producers of plastics resins encourage the use of color standards. Many companies assemble and distribute sample chips or swatches. One has prepared a large group of these in organized form on the principles of color harmony. Another has adopted the ingenious device of preparing transparent chips which can be stacked above an opaque backing, so that a dozen chips will produce hundreds of variations. Still, with several million different colors perceptible to the human eye, anyone with a child's set of water colors can produce dozens of colors not to be found in any prepared set of standards, and plastics manufacturers find themselves constantly matching standards in other materials.

There are legitimate reasons for special colors. It is often difficult to foresee the appearance of a large object in a particular color from its appearance in small scale or a rendering. If a color change is necessary after the prototype is prepared, the only practical method of trial is by painting the model, and the paint must then be matched in the material to be used. Also, plastics are frequently employed in color harmony with less-versatile media. Porcelain enamel is an example. If a color is established on the basis of plastic samples, it may be found later that the necessary harmonizing hue is not easily produced in the other material. The reverse of this is not true.

Economic aspects of color selection should not, of course, override aesthetic considerations. But for most commodities, data are available on what colors are selling in greatest volume. Being guided by such data may limit creativity, but it is usually safer commercially. This is especially true if an article is being produced for volume markets. The majority of buyers in such markets have surprisingly conventional tastes. No matter how many colors are offered in various product lines, four colors or less usually account for 65 to 80 per cent of sales.

00 000 00 000 000 000 000 00

scanning the field for ideas

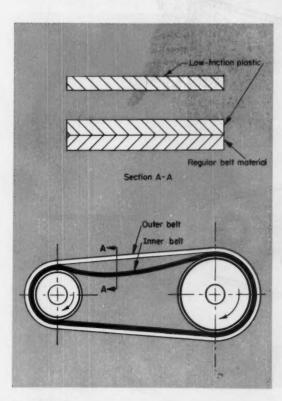


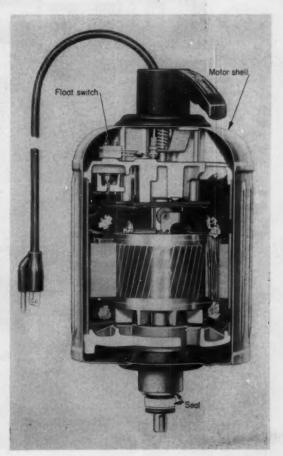
Pulse-actuated permanent memory is provided by bistable magnetic cores in an electromechanical switch requiring no holding power. The magnetic-ferrite core material is switched from one magnetic state to another by a current pulse applied to the coils. Control pulses as short as 5 microseconds will switch the magnetic material, causing the passage of magnetic flux through the movable members of the reed switch. The contacts remain either closed or open until a second switching pulse is applied to the coils. Principle employed in electromechanical switch developed by Bell Telephone Laboratories, New York.

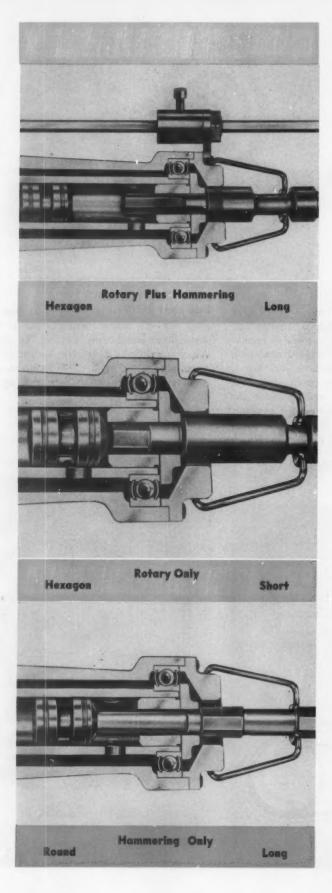


Concentric belts increase power-transmission capacity by individually providing for tension and sheave adhesion. Inner flat belt is made of regular belt material, with the outside surface coated with a low-friction, high-strength plastic. Outer belt is made entirely of the plastic material. Power is transmitted by the inner belt moving inside the stationary outer belt. This arrangement produces belt adhesion to slack side of sheaves, as well as to tension side, thus increasing power-transmission capacity. Principle employed in drive arrangement developed by Chavand, Lyon, France.

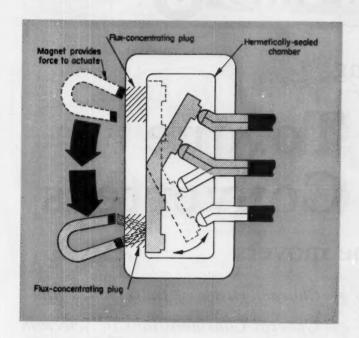
Buoyant shell of motor serves as float for actuating "on-off" switch. Rising water in the pump sump raises sealed shell, turning the pump "on." When water level drops, the weight of the shell moves the switch to the "off" position. Principle employed in sump pump developed by Franklin Electric Co. Inc., Bluffton, Ind.



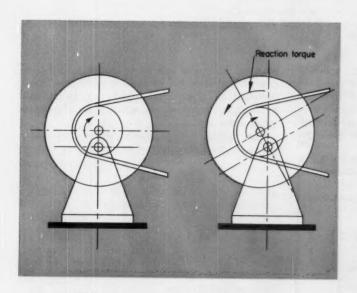




Shaped shank selects automatically the type of motion imparted to a tool. The drive mechanism provides both rotary and hammering motion. Short-hexagon shank connects with rotary motion only. Long-round shank receives hammer blows but allows rotary drive collar to free-wheel. Long-hexagon shank receives both types of motion. Drive principle employed in power hammer developed by Skil Corp., Chicago.



Flux-concentrating plugs in a wall of nonmagnetic stainless steel conduct the flux of an actuating magnet to operate a sealed switch. Movement of the external magnet between preset limits produces a corresponding movement of the internal switching mechanism. Principle employed in electrical switch developed by Space Components Inc., Washington, D.C.



Automatic tensioning maintains belt tension proportional to load. An eccentric mounting arrangement permits the reaction torque to rotate the motor assembly. Thus, the motor and attached sheave are pulled against the belt. The greater the load, the greater the reaction torque and, therefore, the greater the tension. Principle employed in drive belt tensioner developed by Antriebe AG, Rapperswil, Switzerland.

Applying

Torque Converters

to prime movers

- Characteristics of Individual Units
- General Considerations in Selection
- Application to Electric Motors

R. W. BACHMANN

Hydraulic Division Twin Disc Clutch Co. Rockford, III.

SELECTING the unit that will provide optimum performance of an engine-converter combination requires careful evaluation of converter characteristics. Various converter types discussed in this article are applied to an example engine developing 100 hp net at 1800 rpm. Performance character-

istics for this engine are shown in Fig. 1. If the engine performance were given in terms of gross horse-power, 10 to 15 per cent would have to be deducted to obtain net power output, which is the actual converter power input.

The suitability of a match between an engine and a torque converter can be checked as follows:

$$T_1=5250\left(rac{P_1}{N_1}
ight)$$

and

$$T'=T_1\left(egin{array}{c} 1700 \ \hline N_1 \end{array}
ight)^2$$

The value of primary torque calculated from net engine torque should fall on the converter primary curve at a speed ratio somewhere between the point of peak efficiency and the nominal M_s point. For the hypothetical engine,

$$T_1 = 5250 \left(\frac{100}{1800} \right)^2$$

= 292 lb-ft

and

$$T' = 292 \left(\frac{1700}{1800} \right)^2$$

= 260 lb-ft

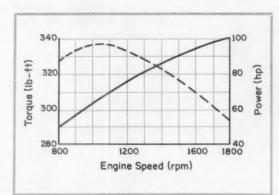


Fig. 1—Performance curves of example engine. The various converters discussed in this article are applied to this hypothetical engine.

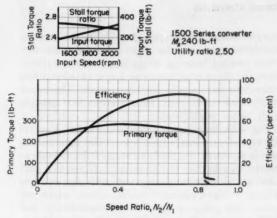


Fig. 2—Primary torque and efficiency curves of a type 1 converter.

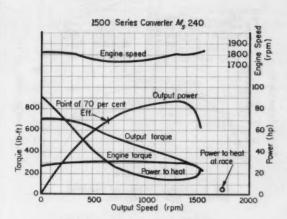


Fig. 3—Output performance curves of engine and type 1 converter.

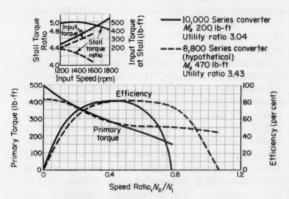


Fig. 4—Primary torque and efficiency curves of three-stage, type 3 converters.

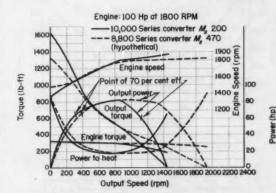


Fig. 5—Output performance curves of engine and three-stage, type 3 converters.

Unit Characteristics

In the following descriptions, converters are identified by type numbers which represent sequential designs. Types 2 and 5 are omitted because these designs did not prove feasible for production. Identification systems are not standardized and vary among manufacturers.

Type 1 Single-Stage: This converter is suitable for certain light-duty applications. It has a decreasing primary-torque absorption curve at low-speed ratios approaching stall, and "unloads" almost completely (ceases to absorb torque) at about 0.85 speed ratio. Fig. 2 shows the primary torque and efficiency curves of an average capacity Type 1 converter.

The primary torque equivalent of 260 lb-ft of the example engine at 1800 rpm falls on the primary curve at 0.725 speed ratio and 86 per cent efficiency. This point is at peak efficiency and would be considered an excellent match of converter to engine. Fig. 3 shows the resultant output characteristics, and engine speed, plotted against output-shaft speed.

The converter does not pull down engine speed appreciably. In fact, the engine-speed curve rises again at low output speed, as the converter output is loaded toward stall.

Power to heat is a characteristic not ordinarily plotted on a performance curve, but is useful in cooling studies. The ratio can be found by subtracting output power P_2 from input power P_1 at any given speed ratio or point of calculation. The ratio can then be plotted against output speed. Although this converter unloads at about 0.85 speed ratio, a small amount of horsepower is still absorbed at race. This power is dissipated as heat.

Type 3 Three-Stage: This converter has a sta-

Nomenclature

M_s = Specific torque, lb-ft

 $N_1 = \text{Converter input speed, rpm}$

 $N_2 =$ Converter output speed, rpm

P1 = Converter input power, hp

T' = Primary torque, torque absorbed by impeller at 1700 rpm input speed, lb-ft

 $T_1 = \text{Converter input torque, lb-ft}$

 $T_2 = \text{Converter output torque, lb-ft}$



1700 Series converter (hypothetical) M. 400 lb-ft Utility ratio 3.02 Input Speed (rpm) Primary Torque (Ib-ft) **Efficiency** cent) 80 Primary torque Efficiency (per 60 300 200 100 20 Speed Ratio, No. /N. Fig. 6—Primary torque and efficiency

curves of type 4 converter.

1700 Series converter M_s 400 (hypothetical) 1400 1900 1800 E 1700 E Engine speed Point of 70 per cent eff. 1000 100 Torque (Ib-ft) Output power 800 80 (ph) 60 Output torque 400 40 Engine 20 800 1600 Output Speed (rpm)

Fig. 7—Output performance curves of engine and type 4 converter.

500 00 1500 Series converter Ms 280 lb-ft Input torque Utility ratio 2.63 1400 1600 1800 2000 100 Primary Torque (1b-ft) Efficiency cent) 400 80 Primary torque (per 60 Efficiency 200 40 100 0.6 Speed Ratio No /No

Fig. 8—Primary torque and efficiency curves or type 6 converter.

1500 Series converter M. 280 1900 Engine speed 1600 4 1500 1100 1000 Output power 80 Torque (Ib-ft) Point of 70 per cent ef (hp) 60 600 utput torque 40 400 20 200 800 1600 Output Speed (rpm)

Fig. 9—Output performance curves of engine and type 6 converter.

tionary housing and provides higher stall-torque multiplication than the type 1 converter or any other rotating-housing, single-stage converter. Further, the three-stage converter has a broader utility ratio than most single-stage converters. The broad utility ratio is inherent in converters that provide high torque multiplication.

Fig. 4 shows primary torque and efficiency curves for typical three-stage converters. The solid curves, which represent the characteristics of the lowest capacity unit in the 10,000 series, indicate that this unit would make a good match with the example engine. The engine would reach maximum power and governed speed at 0.48 speed ratio and 81.5 per cent efficiency. The solid curves, Fig. 5, show the output performance with this match.

Units with various capacities in a given series of three-stage converter do not run out or race at the same speed ratio. For example, the 10,000 series M_s -200 runs out at 0.78 speed ratio. The highest M_s ratings, however, may run out at 1.0 speed ratio or above.

A comparison of a high M_s converter with a low M_s converter in the 10,000 series would show that the high M_s unit is of such greater capacity that it would make a very poor match with the example engine. To make an M_s comparison with the same engine, however, a converter of the 10,000 series could be "scaled-down" to a smaller diameter, creating a new hypothetical size that would properly match the example engine. Since torque capacity varies as the fifth power of the circuit diameter, the torque capacity of a converter with a diameter constant of 0.88, instead of 1.0, would be 0.528 times that of the larger diameter converter.

The dashed curves in Fig. 4 show the estimated performance of such a scaled-down converter. The required primary torque of 260 lb-ft is matched by this converter at 0.66 speed ratio and 80.5 per cent efficiency. The dashed curves, Fig. 5, indicate the broad range of high output horsepower available with the high $M_{\rm e}$ unit. Converter stall-torque multiplication is somewhat less with this converter, however.

Generally, the three-stage converter provides greater engine-speed pull-down than most of the single-stage converters. Such pull-down brings the engine closer to its peak torque point at converter stall, adding to the effective torque multiplication.

In converters which do not abruptly unload near race, the power to heat continues to increase as efficiency drops off near race. The high M_a converter has higher power to heat at race because the torque absorption does not fall off at high speed-ratios as fast as it does in the low M_a converter.

The scaled-down converter is hypothetical and is discussed only to illustrate the possible differences in characteristics between high and low M_{σ} ratings. These differences can exist when different series of a given type of converter overlap.

Type 4 Single-Stage: This stationary-housing converter, like the three-stage, has high torque multiplication, various runout speed-ratios in a given series, and does not unload at race. However, it differs in one important characteristic. The primary-torque absorption of the type 4 is relatively constant and drops off slightly toward stall.

Fig. 6 shows the primary torque and efficiency of an average capacity type 4 unit "scaled up" to permit performance comparison. For a given engine, the type 4 converter must have a circuit diameter greater than those of the other single-stage converters because the outlet of the impeller is closer to the axis of the converter.

Because of the relatively flat primary-torque curve, a type 4 converter can be matched to an engine at a speed ratio greater than the speed ratio corresponding to the nominal M_{\bullet} point, if necessary. Fig. 7 shows estimated performance of the example engine with the hypothetical type 4 converter.

Type 6 Single-Stage: Similar to type 1 in construction, type 6 differs in that the stator blades are placed so that fluid flows from the turbine inward through the stator toward the center, rather than outward through the stator into the impeller. The type 6 converter runs out at about 1.15 speed ratio, provides moderate engine pull-down, and has higher stall-torque ratio than type 1. Fig. 8 shows primary torque and efficiency curves of an average capacity type 6 converter.

The 100-hp example engine would match the type 6 converter shown at 0.92 speed ratio and 80 per cent efficiency. Fig. 9 shows performance characteristics with this match. The characteristic of running out beyond 1.0 speed ratio provides good high-speed performance.

The power-to-heat curve shows one advantage of unloading at race. Since the power absorption decreases, the heat that must be dissipated decreases rapidly toward race, even though efficiency is also decreasing.

Type 7 Single-Stage: This converter combines the stator arrangement of types 1 and 6. The type 7 converter runs out at about 1.0 speed ratio, has higher stall torque than type 6, and gives moderate engine pull-down. Fig. 10 shows primary torque and efficiency curves of an average capacity type 7 converter.

The example engine would match this converter at 0.89 speed ratio and 75 per cent efficiency. Fig. 11 shows these performance characteristics.

Type 8 Single-Stage: The stator is mounted on a free-wheel mechanism so that it can "float" or break away from a fixed position when the torque ratio tends to drop below 1:1. This arrangement improves the operating characteristics of the high output-speed range and reduces the power to heat curve. Fig. 12 shows primary torque and efficiency of such a "converter coupling."

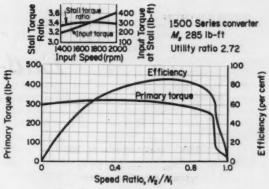


Fig. 10—Primary torque and efficiency curves of type 7 converter.

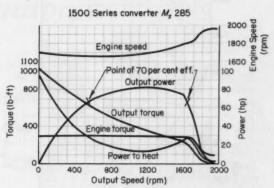


Fig. 11—Output performance curves of engine and type 7 converter.

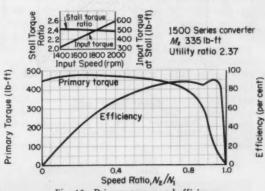


Fig. 12—Primary torque and efficiency curves of type 8 converter.

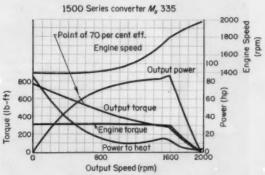


Fig. 13—Output performance curves of engine and type 8 converter.

End-loaders

1300 Series converter M. 280 -- Performance with 25 hp hydraulic pump fully loaded -Performance without hydraulic pump 800 700 600 Speed (rpm) 500 Engine speed (H-di) august 300 1600 Output torque Dutput power Output 200 100 800 1200 1600 2000 2400 Output Speed (rpm) Performance curves of engine-converter combination for end-loader.

Almost all rubber-tired end-loaders manufactured today are equipped with torque converters. The reasons for this complete acceptance are:

1. Prevention of engine stalling.

Continuous variation in torque-speed requirements.
 Ability to effectively crowd and hoist simultaneously.

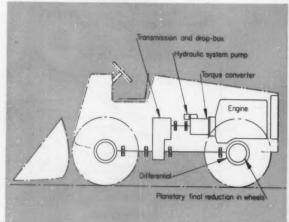
The principal factor affecting the selection of the optimum torque-converter is the high proportion of engine power required by the hydraulic pump. This engine power (sometimes as high as 50 per cent) is required to provide adequate bucket speeds for rapid work cycles.

Because the hydraulic pump is directly connected or geared to the engine, both the pump and the converter may demand power at the same time. If either or both are not properly matched to the engine, excessive engine-speed reduction may occur, causing poor loader performance. Therefore, it is important to make a thorough study to determine the most suitable engine-converter and hydraulic-pump combination as shown by the performance curves. The engine-speed reduction is a minimum without the hydraulic pump, and the engine-speed reduction is moderate with the pump loaded.

Engine-converter performance with the hydraulic pump unloaded can be calculated and plotted after deducting the normal power loss to fan, generator, other accessories. However, to estimate performance when the hydraulic pump is fully loaded, the power required to drive the hydraulic pump must also be deducted. The new net engine-performance must then be used to calculate output performance with the same converter. This procedure was followed for the curves shown.

Normally, the hydraulic pump will not be fully loaded during a major portion of the work cycle. It will be loaded only when the bucket is hoisted or dumped. For example, the engine-converter unit whose performance is illustrated would never operate continuously along the dashed curves. The solid

Drive train of end-loader





Photo, courtesy Allis-Chalmers Mfg. Co.

and dashed curves show only the extremes of the range through which the engine-converter unit can operate as the hydraulic pump load varies.

As indicated by the performance curves, type 6 converters are particularly well suited to end-loader applications. Their mechanical configuration allows simple installation and ease of driving auxiliary pumps. A typical end-loader using an enginemounted torque converter and a midship transmission with integral drop-box is shown. Transmissions are usually partial or full power-shift designs. Those with partial power-shift have forward and reverse friction clutches and manual speed-change jaw

clutches. Others have two-speed power shift options in addition to forward and reverse.

A minimum of three speeds in each direction is necessary for good end-loader performance. Some manufacturers prefer four speeds to obtain greater over-all range and to allow closer spacing of ratios. Loading speeds are 0 to 3.5 mph, while travel speeds (loaded) are approximately 0 to 10 mph. Travel speeds (empty) may reach 25 mph.

As on other earthmoving equipment, the entire cooling problem should be studied carefully. Provision must be made for adequate heat dissipation over the entire normal operating range.

Logging equipment

The logging industry makes use of basic construction and materials-handling equipment very similar to that used in any other industry, but with special features unique to logging.

Yarders—basically multiple-drum hoist or winchtype machines—are used in locations not easily accessible to the crawler-mounted machines because of terrain or slope. A yarder, then, is a more-or-less stationary (but portable) machine which may work in one location for some time.

Hoisting logs of various weights up rough slopes or over rough level terrain can be much more severe service for the yarder power unit than "free" hoisting in open space. The logs can hang up on stumps and rocks and cause severe momentary overloads and shock loads on the machinery. 'Two and three-speed power-shift transmissions are used in conjunction with the torque converters to broaden the working range of the equipment.

Three-stage converters are usually used with yarders. These converters are particularly useful in lowering heavy logs down steep slopes since the retarding characteristics of the converter can be used. When the retarding feature of the converter is used,

additional cooling must be provided. Cooling capacity for 40 per cent of the net engine horsepower is normally provided. Oil-to-air cooling has advantages over oil-to-water cooling in such applications. During periods of light load or idling, the converter fluid will cool considerably with an oil-to-air radiator, allowing for more temperature rise during short overload periods.

Log loaders are essentially crane-type machines. A mobile log-loader is usually equipped with a heelboom. When the log is lifted with the grapple, one end of the log is butted against the boom during swing. This arrangement provides easier handling and placing of the log on a truck. Conventional straight-boom cranes or converted excavator-type machines can be used for log loading. This type operation is called "crotch-line" loading. Early loaders had foot-throttle or hand-throttle speed control. However, an output shaft governor provides more satisfactory speed control of machines equipped with the operator-controlled grapple.

Performance of yarders under these conditions can be estimated in the same way as any other hoist-type machines.



Photo, courtesy Link-Belt Co.

The example engine would match the type 8 converter in the coupling range, at 0.89 speed ratio and 86.3 per cent efficiency. Fig. 13 shows performance characteristics of this match.

The coupling range can best be utilized for highspeed performance by matching at peak efficiency. However, this match reduces converter-range performance. If the engine is matched to the converter at the left of the coupling range, the coupling-range characteristics are still useful in reducing the power to heat at light output loads.

Power Availability

The output power available with the example engine and the three-stage converter is compared to that available from the same engine alone in Fig. 14. The engine power-curve is plotted back to 1000 rpm, the speed at which the engine develops maximum torque. The speed at which maximum torque is produced is the minimum practical operating speed for any engine.

Although peak power output is not as great with the torque converter as with the engine alone, reasonably high power is maintained over a greater range with the converter. This spread of working power can be expressed by "power availability ratio." Assuming that at least 70 hp is to be maintained when the example 100-hp engine is used, with or without a converter, the power availability ratio can be expressed as the ratio of maximum speed at which 70 hp is available to minimum speed at which 70 hp is available.

From Fig. 14, the ratio for the engine alone is 1850/1100 = 1.68. For the engine-converter unit, the ratio is 1440/450 = 3.2—approximately twice as great.

Even for low stall-torque ratio, low utility-ratio

converters such as the type 8, the horsepower availability ratio is greater than with the engine alone, Fig. 15. The horsepower availability ratio for the engine-converter unit is 1665/785 = 2.12.

Selection Factors

No universal rule can be established for matching a converter to an engine. To get the maximum peak-horsepower from the engine-converter combination, it would be advisable to match at peak converter efficiency. However, this match is not always possible with the available sizes and M_* ratings. Frequently, other considerations are more important than peak output horsepower. For example, matching to the right of peak efficiency may sometimes be necessary with the three-stage converter to obtain suitable performance at high output speeds.

There is no point in matching at a speed ratio to the left of the point of peak efficiency, since the engine would be operating on governor overrun at peak converter efficiency. Applications involving intermittently loaded, engine-driven auxiliary pumps of high-power requirements would be an exception. In such cases it may be wise to make a compromise match so that converter output performance would be acceptable with the pump either loaded or unloaded

Matching to the right of peak efficiency is acceptable so long as efficiency is at least 80 per cent at the match point. Matching farther to the right, down to as low as 75 per cent efficiency, is acceptable in some cases if the effects on the engine and the cooling requirements are recognized.

The flatter the primary-torque curve, the farther to the right the engine can be matched to the converter without adverse effects from engine pull-down. A converter with a steep primary-torque curve has

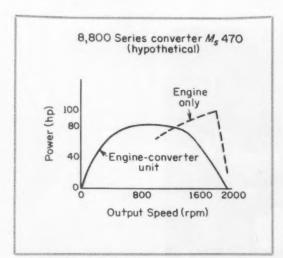


Fig. 14—Power-availability curves for three-stage converter.

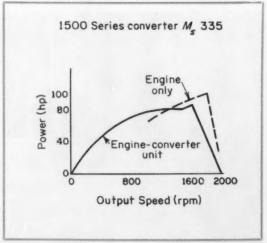


Fig. 15 — Power-availability curves for type 8 converter.

a greater tendency to reduce engine speed below the governed value. This engine pull-down reduces the power input at peak efficiency and reduces fan

and water-pump speed.

Turbocharged engines are designed to operate most efficiently at governed speed. A converter should be matched to a turbo-charged engine to avoid excessive engine-speed reduction. Matching too far to the right, particularly with converters having steep primary-torque curves, may cause excessive engine pull-down.

The location of the match point can affect the converter cooling load. A converter matched far to the right will be absorbing full net engine power at low efficiency. If this match point location is unavoidable, the cooling requirements must be analyzed thoroughly by a study of the power to heat

curve.

Application to Motor

Torque converters can be used also with electric motors. The full-load torque and power at full-load speed (approximately 97 per cent of synchronous speed) of the motor can be considered comparable to the net rating of an engine at governed speed. This full-load rating can be used to calculate an equivalent primary-torque value to use as a match point for selecting a converter.

A converter can be selected for a motor in much the same way as for an engine, except that care must be taken to see that the converter will not pull the motor down to the pull-out torque point at stall. The recommendations of motor manufacturers vary, but in general, most motors should not be loaded to more than 175 per cent of full-load torque. This limitation may require a match to the left of peak efficiency in the case of some of the three-stage converters.

Torque converters reduce the demand for line current at heavy loads. The simple Type-K ac squir-rel-cage motor is satisfactory for use with a converter, because there is no need for the higher starting torque of other types of motors.

The next article in this series will discuss engineconverter performance curves. Other future articles will cover extreme speed ratios; direct-drive, splittorque, and retarding arrangements; cooling systems; and limiting devices.

Tips and Techniques

Drawing Formed-Tubing Parts

Drawings of formed pipe or tubing components are frequently made from actual parts disassembled from the pilot model of a machine. The "gadget" shown in Fig. 1 is an aid to making fairly accurate full-size tracings needed for production drawings, checking clearance for other parts, or for record purposes.

A tee-square blade about 18 in. long is attached

to a wooden base block so that the blade is at 90 degrees to the lower surface of the block. Dimensions of the base are not important, but a piece approximately 5 by 2½ in. by 1½ in. high works well. One corner is removed as shown for clearance in tracing sharp bends. A second block is attached to the opposite side of the blade to support a ballpoint pen refill. The surfaces of the block are cut to a wedge having a 20-degree included angle. The block is positioned so that the pen lines up with the center of the blade. To allow clearance for the pen, the lower corner of the blade is trimmed. Two metal clamps secure the pen to the wedge block. The pen is used rather than a pencil, because a line of infinite length can be made without adjustment.

To use the "vertical tee-square," the tubing to be drawn is securely clamped to a table in the position corresponding to the desired view. The blade is moved carefully along the edge of the tubing, Fig. 2, tracing the outline on the paper below. The tubing is then rotated 90 degrees and again traced for the second view. From the two views an end view is made by projection.—HARRY P. KRULL, Austin-Western Works, Baldwin-Lima-Hamilton Corp., Aurora, Ill.

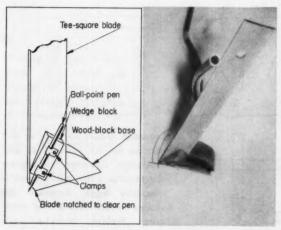


Fig. 1

Fig. 2

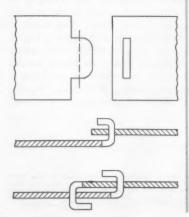
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MacHine Dission, Penton Bidg., Cleveland 13, 0. For quick and easy assembly, design for . . .

FOLDED FASTENING

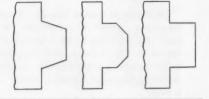
the assembly of toys—which can pay off in many applications.

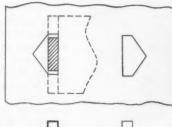
FEDERICO STRASSER Santiago, Chile

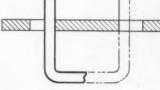
Basic joint is formed when an integral lug on one member is passed through a slot on a second member, then bent over upon itself. Double-strength joint is formed when each member has a lug and slot engaged with mating features on opposite member. Lugs should be bent so that stamping burrs on the edges of lugs are on the inside of the bend.

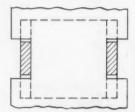


Lug shapes should facilitate assembly. Square type is worst. Tapered or rounded edges help guide lugs into slots.









Lug holes should be large so that punches are not weak. Even with substantial clearance, rectangular slot requires a thin punch which is inherently weak. Remedial slot shapes include round and triangular. Problem punches are avoided if notches can be used.

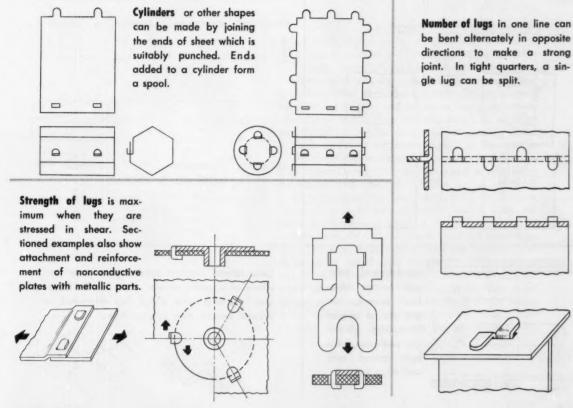
Characteristics of Folded Fastening

Advantages

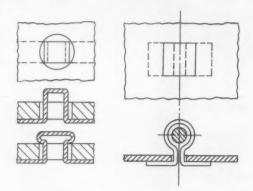
- 1. Separate fasteners, such as screws and rivets, are not required.
- 2. Preparatory operations, such as punching and trimming, are few and simple.
- Assembly operations, both manual and mechanical, are inexpensive and brief.

Limitations

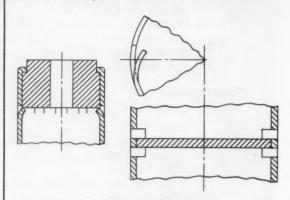
- 1. Joints are suitable mainly for low strength requirements.
- 2. Range of stock thickness is limited. Recommended thickness lies between 0.012 and 0.080 in.
- 3. Minimum tab and hole sizes depend on sheet thickness.
- 4. To avoid faults caused by springback, metal must be comparatively soft. Metals used are steel, brass, aluminum, and copper all in annealed, soft state.



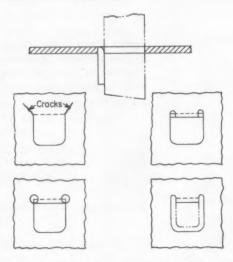
Strip stock can be secured to a surface without separate fasteners. U-shaped lengths of the strip can be led into round holes and flattened. Lengths of folded strip form wire retainers.



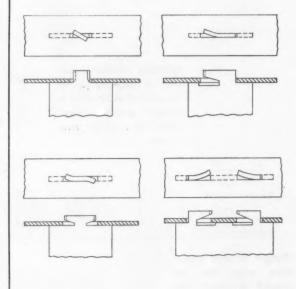
Partial lancing, in which punches do not pass completely through the workpiece, produces indentations which are useful as positioners. An insert can be wedged against a lip in the end of a tube, and a disc can be positioned between the ends of a tube.

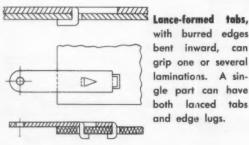


Lancing is a punching operation which forms tabs anywhere within the boundaries of a sheet, rather than at the edges only. A beveled punch progressively cuts three sides of tabs and bends the tabs perpendicular as it continues through the punched hole. In thick stock, 0.04 in. or more, cracks may develop at corners of tabs. Stress which causes cracking is relieved by elongated holes or round holes at the base of the tabs, or by a border punched around each tab.



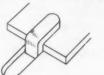
Twisted tabs are suitable where sheet stock is thick and where joined parts are respectively perpendicular. Simplest design is a straight lug twisted at its top. But due to its height, this lug is a hazard. Undercut types are lower-hence, safer-and wedged in place by inclined edges on the bent projections.





with burred edges bent inward, can grip one or several laminations. A single part can have both lanced tabs and edge lugs.

Lance-formed retainers hold strip or plate anywhere on a metal surface. Tabs can be folded over, exposing holes where they originated, or pressed toward their original holes.





MACHINE DESIGN

BEAMS

AUSTIN H. CHURCH

Chairman, Mechanical Engineering Dept. College of Engineering New York University New York, N. Y. BEAMS are examples of vibrating systems in which stiffness and mass are distributed rather than being concentrated at discrete points. Vibration problems in such systems can be solved by conventional methods; however, the calculations involved are lengthy and tedious unless a high-speed computer is used. Two methods based on mobility techniques have been developed to simplify beam analysis and will be demonstrated in this article.

One simplified procedure of analysis is based on the displacement mobility¹ of the beam and may be called the "receptance" method.^{6,7,8} The second technique is the normal-mode mobility method which has been discussed in previous articles^{2,3,4} and is fully developed in References 9 and 10.

Both methods will, of course, give the same solution. The receptance method does not require determination of the natural frequencies of the system, but the normal-mode mobility method does. On the other hand, if loads are applied, or response is required, at points other than the ends of the beam, tables developed for the normal-mode method can be used directly. Such tables are not available for

¹References are tabulated at end of article.

the receptance method, and the values must be calculated, adding to the work involved.

Basic Theory: The differential equation of motion of a vibrating beam has been generally derived as11,12,13.

$$\frac{\partial^2 y}{\partial t^2} + \frac{EIg}{A\gamma} \frac{\partial^4 y}{\partial x^4} = 0$$
 (79)

If excitation is harmonic, solution of this equation

$$y=y_o\sin\omega t$$

Substituting this expression into Equation 79,

$$\frac{d^4y_o}{dx^4} - \frac{\omega^2 A \gamma}{EIg} y_o = 0 \tag{80}$$

General solution of Equation 80 is

$$y_o = A \cos \lambda x + B \sin \lambda x +$$

$$C \cosh \lambda x + D \sinh \lambda x$$
 (81)

where

$$\lambda = \left(\frac{\omega^2 A \gamma}{E I g}\right)^{\frac{1}{4}} = \left(\frac{\omega^2 w}{E I g}\right)^{\frac{1}{4}} \tag{82}$$

The constants of integration, A, B, C, and D, in Equation 81, are a function of the boundary conditions of a beam. Boundary conditions for different end conditions of beams are given in Table 9.

The relationships defined by Equations 79 through 82 and the equations in Table 9 are sufficient to find the response of all beams. However, the calculations involved are lengthy and offer many chances for error. Hence, use of the tables of calculated values

and simplified formulas developed for various beam conditions is recommended.

Receptance Method: Although it is based on the displacement-mobility method, the receptance method was developed using the Greek letters a, B, etc., to designate receptances. This convention will be followed here.

Solutions of Equation 80 for uniform-section beams with end excitation and various combinations of end conditions have been tabulated.6,14 Table 10 presents formulas for receptances at the ends of uniform-section beams with various end conditions. Excitation may be in the form of a harmonic force, F, or a harmonic torque, T. Response may be in the form of a displacement, y, or a slope, θ .

In Table 10, receptances, α, are identified with two subscripts. The first subscript indicates the point

Table 9—Basic Equations for Different Beam **End Conditions**

End Condition	Basic Equation		
		dy,	- 0
Clamped end	y_o -	$\frac{dy_o}{dx}$	- 0
Pinned end		d^2y_o	= 0
	$y_o =$	dx^2	
Sliding end		d^3y_o	
	dx	dx^3	- 0
Free end	d^2y_o	$= \frac{d^3y_o}{dx^3}$	0
	dx^2	dx^3	- 0

Nomenclature				
A = Area, sq in.	y = Linear displacement, in.			
C = Mode constant (Fig. 33)	$\mathbf{Z}_V = \text{Velocity impedance, lb-sec per in.}$			
d = Diameter, in.	$\alpha = Receptance$			
E = Young's modulus of elasticity, psi	β = Receptance; ratio of impressed to natural frequency			
$E_K = $ Kinetic energy	$\gamma = Density$, lb per cu in.			
F = Force, lb	• = Slope, rad			
f = Cyclic frequency, cps	$\lambda =$ Beam frequency factor (Equation 82)			
g = Acceleration of gravity, in per sec per sec	φ = Phase angle between displacement and force vec-			
I = Sectional moment of inertia	tors, deg or rad			
i = Number of mode shape	ω = Circular or angular frequency, rad per sec			
j = Imaginary operator				
= (-1)%	Subscripts			
L = Length of beam, in.	C = Combined			
and the same of th	D : - f 1: 1			

U	_	Count	meu		
-	-	Daims	-f	1:1	

Point of applied excitation

h = Midpoint of beam

i = Mode number; effective value at mode number

m = Mass

n = Natural or resonant

o = Characteristic

q = Quarter-point of beam

r = Point of response

x = Point on a beamI = Mode number

x =Linear displacement, in.

v = Velocity, in. per sec

 $M_V = \text{Velocity mobility, in. per lb-sec}$

Q = Amplification factor at resonance

w = Weight of unit length of beam, lb per in.

 $m = Mass, lb-sec^2 per in.$

t = Time, sec

N = Beam factor (Table 11)

T =Torque or moment, lb-in.

Table 10-Formulas for End Receptances of Uniform-Section Beams*

Beam Cype of	Beam System - Type of End	900	0,00	aro	ar.0	Receptance and	aro,	αΓ,0,	αΓΓ	aL'L	ar,r,
Support	Conditions	}	400	700	aor,		T.OD	α0.Γ.	1	αΓΓ	
Free	x = 0	-N ₅	-N1	N ₈	N ₁₀	N ₆	-N ₁₀	N7	-N ₅	N_1	N ₆
Free	x = T	$EI\lambda^3N_3$	$EI\lambda^2N_3$	$EI\lambda^3N_8$	$EI\lambda^2N_3$	EINN3	EI N2N3	$EI\lambda N_3$	$EI\lambda^3N_3$	$EI\lambda^2N_3$	$EI\lambda N_3$
Clamped	x = 0					A CONTRACTOR OF THE PROPERTY O			-N ₅	N_1	N_6
Free	x = T								EI N3N4	$EI\lambda^2N_4$	EINN4
Clamped	x = 0										N ₃
Pinned	x = T										EINNS
Free	a = 0	$2N_1$	$-N_6$		$-N_7$	$2N_2$		N ₉			N ₄
Pinned	x = L	$EI\lambda^3N_5$	$EI\lambda^2N_\delta$		$EI\lambda^2N_5$	$EI\lambda N_5$		$EI\lambda N_5$			$EI\lambda N_5$
Free	x = 0	$-2N_2$	N_5	-N ₉		$2N_1$	-N ₈		-N ₄		and the state of t
Sliding	x = L	$EI\lambda^3N_6$	$EI\lambda^2N_6$	$EI\lambda^3N_6$		EINNS	EI \2N6		$EI\lambda^3N_6$		
Pinned	x = 0					$-N_5$		N_8			-N ₅
Pinned	x = T					$2EI\lambda N_1$		$2EI\lambda N_1$			2EINN1
Sliding	0 = x	-N ₅			N10						N ₆
Pinned	x = L	2EI\3N2			$2EI\lambda^2N_2$						$2EI\lambda N_2$
Clamped	x = 0								-N ₃		
Sliding	x = L				All the state of t				EI N3N6		
Sliding	x = 0	$-N_6$		$-N_7$					-N ₆		
Sliding	x = T	$2EI\lambda^3N_1$		$2EI\lambda^3N_1$,	2EIN3N1		

*Based on References 6 and 14.

on the beam where response is measured. The second subscript indicates the point of excitation. Subscripts with primes refer to slope or moment; subscripts without primes refer to displacement or force. Thus, $\alpha_{sL'}$, indicates a receptance in the form of a displacement at point x on the beam as the result of a moment applied at the end of the beam which has a length, L. By reciprocity, $\alpha_{sL'} = \alpha_{L's}$.

Formulas in Table 10 include an N function, which is a combination of trigonometric and hyperbolic functions. Equations for determining the values of these N functions, once the values of λx or λL are known, are given in Table 11. The value of λ is obtained from Equation 82. Tables of calculated values of N for various values of λL have also been developed. 6.14

Thus, values of receptance can be calculated for any value of impressed frequency. They do not require determination of the system natural frequencies.

Three examples will be presented to illustrate the application of the receptance method of analysis to simple, stepped, and continuous beams. Two steel beams of constant circular cross section will be used in these examples. Their dimensions and properties

Beam A:
$$d=0.805$$
 in.; $I=0.0206$ in.⁴; $w=0.144$ lb per in.; $L=10$ in.; $(w/EIg)^{\frac{1}{16}}=0.005$; $\lambda=0.005$ $\omega^{\frac{1}{16}}$; $\lambda L=0.05$ $\omega^{\frac{1}{16}}$.

Beam
$$B: d = 0.2015$$
 in.; $I = 80.8(10)^{-6}$ in.⁴; $w = 0.009$ lb per in., $L = 10$ in.; $(w/EIg)^{\frac{1}{16}} = 0.01$; $\lambda = 0.01$ $\omega^{\frac{1}{16}}$; $\lambda L = 0.1$ $\omega^{\frac{1}{16}}$.

Example 1: Assume that beam A is free-pinned,

$$egin{aligned} N_1 &= \sin\lambda\,L\,\sinh\lambda\,L \ N_2 &= \cos\lambda\,L\,\cosh\lambda\,L \ N_3 &= \cos\lambda\,L\,\cosh\lambda\,L - 1 \ N_4 &= \cos\lambda\,L\,\cosh\lambda\,L + 1 \ N_5 &= \cos\lambda\,L\,\sinh\lambda\,L - \sin\lambda\,L\,\cosh\lambda\,L \ N_6 &= \cos\lambda\,L\,\sinh\lambda\,L + \sin\lambda\,L\,\cosh\lambda\,L \ N_7 &= \sin\lambda\,L + \sinh\lambda\,L \ N_8 &= \sin\lambda\,L - \sinh\lambda\,L \ N_9 &= \cos\lambda\,L + \cosh\lambda\,L \ N_{10} &= \cos\lambda\,L - \cosh\lambda\,L \ N_{10} &= \cos\lambda\,L - \cosh\lambda\,L \end{aligned}$$

Fig. 30, and that a harmonic moment, $T_e = 10$ lb-in., is applied at the free end (x = 0) with a frequency $\omega = 6400$ rad per sec. Find the response amplitude of the slope at the pinned end.

From Table 10, receptance $\alpha_{L'o'}$ for a free-pinned beam is

$$\alpha_{L'O'} = \frac{N_9}{EI\lambda N_5} \tag{83}$$

When $\omega = 6400$ rad per sec, $\lambda L = 0.05\omega^2 = 4$, and $\lambda = 0.005\omega^2 = 0.4$. Then, from Table 11, $N_5 = 2.83$ and $N_9 = 26.65$. Solving Equation 83,

$$a_{L'O'} = \frac{\theta_L}{T_e} = \frac{26.65}{29(10)^6(0.0206)(0.4)(2.83)}$$

$$= 39.5(10)^{-6}$$

Maximum slope at the pinned end is readily deter-

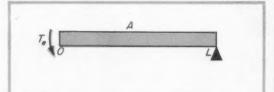
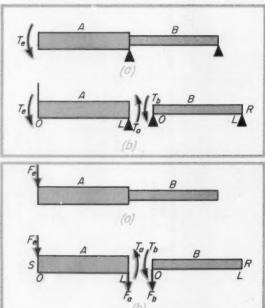


Fig. 30 — Free-pinned beam with harmonic moment applied at free end.

Fig. 31 — Simple beam combination with harmonic moment applied at free end of overhung portion of the system. Complete system is shown at a, subsystem breakdown at b.

Fig. 32 — Combination system acting as a single free-free beam with harmonic force applied at one end. Complete system is shown at a, subsystem breakdown at b.



^{*}Based on References 6 and 14.

mined from

$$heta_L = T_e a_{L'O'} = 10(39.5)(10)^{-6} = 0.000395 \text{ rad}$$

$$= 0.0226 \text{ deg}$$

EXAMPLE 2: Assume that beam B is welded to beam A and that the combination acts as a simple beam with beam A overhung, Fig. 31a. Find the slope at each support if the applied moment at the free end of the system is $T_e = 10 \sin 6400t$.

For analysis, the complete system may be divided into subsystems A and B, Fig. 31b. At the welded joint, or at the left-hand support, internal moments T_a and T_b are induced as shown. The slope of both beams is the same. Then,

$$\theta_a = \theta_b$$

$$T_a + T_b = 0$$

Considering beam A as a free body,

$$\theta_a = \alpha_{L'D'} T_e + \alpha_{L'L'} T_a \tag{84}$$

Considering beam B as a free body,

$$\theta_b = \beta_{0'0'} T_b \tag{85}$$

where β is the receptance of beam B.

For beam A (free-pinned), $\lambda L = 0.05(6400)\% = 4$ and $\lambda = 0.4$. When the appropriate receptance formulas are selected from Table 10, the required N functions are N_4 , N_5 , and N_9 . From Table 11 for $\lambda L = 4$, $N_4 = -16.85$, $N_5 = 2.83$, and $N_9 = 26.65$. Substituting these N values into the receptance formulas,

$$\alpha_{L'0'} = \frac{N_9}{EI\lambda N_5} = \frac{26.65}{29(10)^6(0.0206)(0.4)(2.83)}$$

$$= 39.5(10)^{-6}$$

$$\alpha_{L'L'} = \frac{N_4}{EI\lambda N_5} = \frac{-16.85}{29(10)^6(0.0206)(0.4)(2.83)}$$

Similarly, for beam B (pinned-pinned), $\lambda L=0.1(80)=8$, $\lambda=0.8$, $N_1=1475$, $N_5=-1691$, and $N_8=-1489$. Receptance is

$$\beta_{0'0'} = \frac{-N_5}{2EI\lambda N_1}$$

$$= \frac{1691}{2(29) (10)^6 (80.8) (10)^{-6} (0.8) (1475)}$$

$$= 306 (10)^{-6}$$

 $=-24.95(10)^{-6}$

Substituting these receptance values for beams A and B into Equations 84 and 85,

$$\theta_a = (39.5 \ T_e - 24.95 \ T_a) 10^{-6}$$
 $\theta_b = 306 (10)^{-6} \ T_b$

Also,
$$T_a=10$$
, $\theta_a=\theta_b$, and $T_a=-T_b$. Then, $T_a=-1.4$ lb-in. $T_b=1.4$ lb-in.

$$\theta_a = \theta_b = 430(10)^{-6} \text{ rad} = 0.0246 \text{ deg}$$

Slope θ_R at the right support is obtained from

Table 12-Mode Constants and Node Positions for First Five Mode Shapes of Simple Beams

 $f_n = C[EIg/(wL^4)] \%$

Beam Type	Mode I	Mode II	Mode III	Mode IV	Mode V
Cantilever	C = .56	C = 3.51	C = 9.82	C = 19.24	721 580 277 style C = 31.81
Simply supported ends	C = 1.57	C = 6.28	C = 14.14	C = 25.13	.00 .40 .40 .20 + L C = 39.27
Fixed ends	C = 3.56	.500 +L C = 9.82	.M1 .390 + L C = 19.24	.m 3 .m + L C = 31.81	.773 .991 .489 .327 — L C = 47.52
Free ends	C = 3.56	C = 9.82	000 544 356 050 L C = 19.24	927 .723 .930 .277 .5794.L C = 31.81	C = 47.52
Fixed-hine 4	C = 2.45	C = 7.95	C = 16.59	206 AF1 225 + L C = 28.37	712 S71 AN 180 - L
Hinged-free	C = 2.45	C = 7.95	C = 16.59	C = 28.37	C = 43.30

Reprinted with permission from: C. R. Freberg and E. N. Kemler-Elements of Mechanical Vibration, John Wiley & Sons Inc., New York, 1949.

$$\theta_R = \beta_{L'O'} T_b$$

where

$$\beta_{L'0'} = \frac{N_8}{2EI\lambda N_1}$$

$$= \frac{-1489}{2(29) (10)^6 (80.8) (10)^{-6} (0.8) (1475)}$$

$$= -269 (10)^{-6}$$

Thus.

$$\theta_R = -269(10)^{-6}(1.4) = -378(10)^{-6} \text{ rad}$$

= -0.0216 deg

This method of solution could be extended to include any number of spans of a continuous beam.

Example 3: Assume that beams A and B are welded end to end and act as a single free-free beam with harmonic force $F_e = 10 \sin 6400t$ applied at one end, Fig. 32a. Find the transverse response at the joint and at the ends of the system.

Here again, the system may be divided into two subsystems, Fig. 32b. Internal moments T_a and T_b , and also internal shear forces F_a and F_b , are induced at the juncture.

The following equations may be written for this beam system:

$$T_a + T_b = 0 ag{86}$$

$$F_a + F_b = 0 ag{87}$$

$$x_a = x_b \tag{88}$$

$$\theta_a = \theta_b$$
 (89)

$$x_S = \alpha_{OO} F_c + \alpha_{OL} F_a + \alpha_{OL} T_a \tag{90}$$

$$x_a = \alpha_{LO} F_e + \alpha_{LL} F_a + \alpha_{LL} T_a \tag{91}$$

$$x_b = \beta_{00} F_b + \beta_{00} T_b \tag{92}$$

$$x_R = \beta_{LO} \, F_b + \beta_{LO} \cdot T_b \tag{93}$$

$$\theta_a = \alpha_{L'O} F_c + \alpha_{L'L'} T_a + \alpha_{L'L} F_a \tag{94}$$

$$\theta_b = \beta_{0'0} F_b + \beta_{0'0'} T_b \tag{95}$$

Values of the various receptances, α and β , may be found from Tables 10 and 11 as outlined in the previous example. If these receptance values and the known force, $F_o = 10$, are substituted into Equations 90 to 95, values of F_a , F_b , T_a , and T_b can be found from Equations 86 to 89. Then, Equations 90 to 95 may be solved for the desired responses. The complete calculations are lengthy and will be omitted here.

Normal-Mode Mobility Method: As applied to undamped beams, the normal-mode mobility method follows the same approach outlined for lumped systems. A rigorous discussion of the underlying beam theory involved is given in the Appendix of Reference 9.

A beam has an infinite number of natural frequencies. Each natural frequency is characterized by a unique mode shape with specific node positions, Table 12. In this table, odd-numbered modes are

characterized by a mode shape that is symmetrical about the midpoint of the beam. Even-numbered modes have antisymmetrical shapes.

If a beam is excited at some frequency that is not a natural frequency, resultant shape of the amplitude-deflection curve is composed of the algebraic sum of the normal-mode shapes. Predominance of each mode shape on the resultant curve is determined by the ratio of impressed frequency to natural frequency for that mode. This point is made quite clear by use of the normal-mode method of analysis.

Predominance of a given mode shape is also a function of the position of the point of excitation along the beam relative to the node positions for the mode shape considered. Thus, if the point of excitation coincides with the position of a node for a particular mode shape, no response will be developed by that mode. This effect is introduced in the calculation of effective mass of the beam.

The expression for velocity mobility of an undamped beam may be written in the form of Equations 63, 64, and 65,4 except that now the number of modes is infinite. Therefore,

$$M_{V} = \frac{v_{o}}{F_{o}} = \sum_{i=1}^{i=\infty} \frac{M_{Voi}}{\beta_{i} - \frac{1}{\beta_{i}}}$$

$$= \sum_{i=1}^{i=\infty} \frac{1}{Z_{Voi} \left(\beta_{i} - \frac{1}{\beta_{i}}\right)}$$
(96)

where M_{Vol} is the characteristic mobility, and Z_{Vol} is the characteristic impedance, based on effective mass m_i for mode i. In the form of Equation 29,²

$$M_{Vol} = \frac{1}{m_i \, \omega_i} \tag{97}$$

or

$$Z_{Voi} = m_i \,\omega_i \tag{98}$$

Before Equation 96 can be used to determine response, the value of effective mass, m_i , of the beam must be calculated for each mode, i. As noted previously in the normal-mode mobility method,³ this effective mass is the magnitude of a single mass which vibrates at a given natural frequency and which has the same kinetic energy as the beam when referred to the point where response is measured and excitation is applied.

Maximum kinetic energy of the beam is

$$E_{K\,({
m max})} = rac{1}{2} \, m \, v_o^2 = rac{1}{2} \, \omega_i^2 \! \int \phi_i^2(\xi) \, \mu(\xi) \, d\xi \, (99)$$

where ξ is distance to any point along the beam, $\phi_i(\xi)$ is the mode shape of mode i, and $\mu(\xi)$ is mass distribution along the beam.

Effective mass has a maximum kinetic energy of

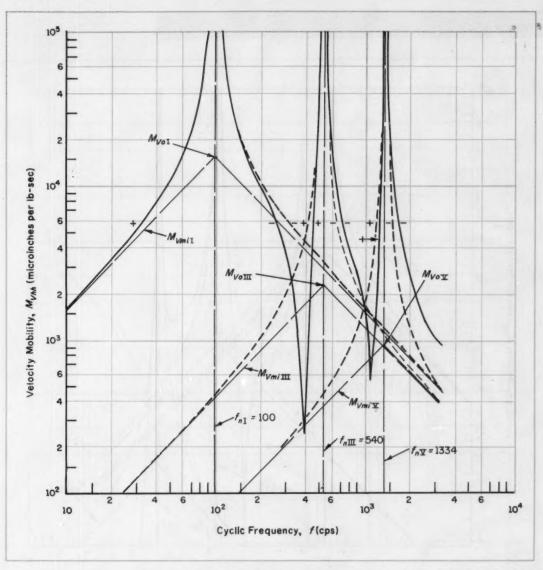


Fig. 33—Driving-point velocity mobility at the midpoint of beam in Example 4. Resultant response is obtained by algebraic addition of responses for each mode.

$$E_{K\,(\text{max})} = \frac{1}{2} m_i \, \omega_i^2 \, \phi_i(x_e) \, \phi_i(x_r)$$
 (100)

where x_e is the value of ξ at which excitation is applied and x_r is the value of ξ at which response is measured.

Setting Equation 99 equal to Equation 100 and solving for effective mass,

$$m_i = \frac{1}{\phi_i(x_r) - \phi_i(x_e)} \int \phi_i^2(\xi) - \mu(\xi) d\xi$$
 (101)

If driving-point velocity mobility is required, $\phi(x_e) = \phi(x_r)$ and Equation 101 becomes

$$m_i = \frac{1}{\phi_i^2(x_e)} \int \phi_i^2(\xi) \ \mu(\xi) \ d\xi$$
 (102)

Values of characteristic functions of the normal modes of uniform-section beams with various combinations of end conditions have been calculated and tabulated in References 14 and 15. In these tables, $\phi_i(\xi)$ is normalized so that

$$\int_0^L \phi_i^2(\xi) \ d\xi = L$$

Then, Equation 101 becomes

$$m_i = \frac{\mu L}{\phi(x_r) \quad \phi(x_e)} \tag{103}$$

where μL is total mass of the beam.

Application of the normal-mode mobility method will be illustrated with an example.

Example 4: A uniform section clamped-clamped beam with a total weight of 100 lb has its lowest natural frequency at 100 cps. The beam is driven at the midpoint $(x/L = \frac{1}{2})$ by a harmonic force. Find the driving-point velocity mobility, or response

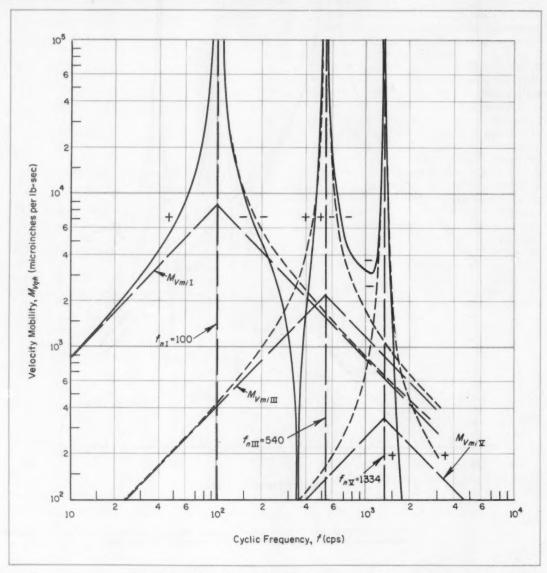


Fig. 34—Transfer velocity mobility at the quarter-point of beam in Example 4. Resultant response is obtained by algebraic addition of responses for each of the three modes.

at the midpoint, as well as velocity mobility at the quarter-point $(x/L = \frac{1}{4})$.

First five mode shapes and location of the nodes are shown in Table 12 for a beam with "fixed ends." Ratios of the natural frequencies can be found from the ratios of the C values in Table 12. Tables of these ratios have been developed by others. \(^{14}\).15 Values of $\phi(x)$ for $x/L = \frac{1}{4}$ and $x/L = \frac{1}{2}$ for the first five modes are given in the third and fourth columns of Table 13. Values of driving-point and transfer effective masses divided by total mass of the beam have been calculated from Equation 103 and are also given in Table 13.

The larger the effective mass, m_i , the lower the

mobility or response for a given impressed vibratory force. Since m_i is infinite for the second and fourth modes, the beam will have no response at these frequencies. For the fixed-end beam, Table 12, a node is shown at the driving point for these frequencies.

Resultant response of the beam for a given impressed frequency is composed of the responses of each mode acting independently. Thus, mobility curves for each mode may be drawn and then added algebraically to obtain the system response or mobility at a given point. This procedure is illustrated in Fig. 33 for driving-point mobility, and in Fig. 34 for transfer mobility.

Characteristic mobilities may be found graphically

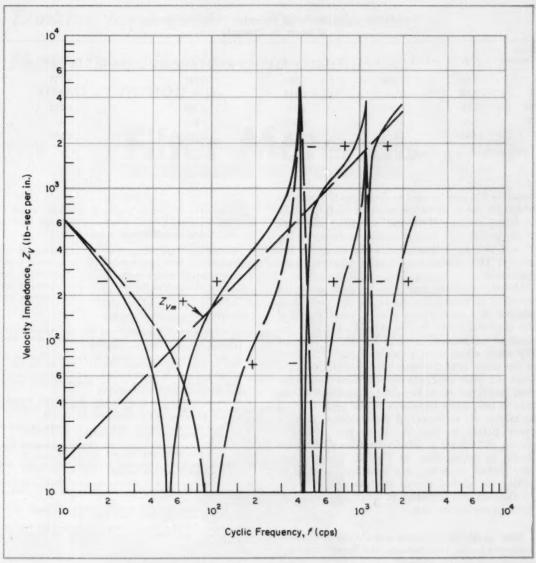


Fig. 35—Velocity-impedance spectrum for the beam response given in Fig. 33 when a concentrated mass is added at the midpoint where excitation occurs.

from Fig. 33 and 34 at the intersection of the effective-mass velocity-mobility line with the corresponding natural-frequency line for each mode. Characteristic mobilities can also be calculated from Equation 97. Thus, for the characteristic driving-point velocity mobility of the first mode,

$$M_{\mathrm{VoI}} = rac{386}{39.7 (100) \, (2) \, \pi} = 0.0155 \; \mathrm{in. \; per \; lb-sec}$$

Modal curve shape is given by Equation 96 for an undamped system. A template for the modal velocity-mobility curve may be constructed and used to facilitate drawing of these curves. This template could be the same one used for the undamped lumped systems if the scale of logarithmic paper is unchanged.

Velocity mobility or response at the quarter point $(x/L = \frac{1}{4})$ can be obtained in a similar manner except that values for effective masses, $m_{iqh}/\mu L$, are taken from the last column of Table 13.

Response with a small amount of damping may be found by writing Equation 96 in the form of Equation 34²; that is,

$$M_{VC} = \frac{M_{Vo}}{\left[\frac{1}{Q^2} + \left(\beta - \frac{1}{\beta}\right)^2\right]^{\frac{1}{16}}}$$
(104)

Table 13—Calculated Data for First Five Modes of Beam in Example 4.

				*	
Mode Number	f_i/f_1	$\phi_i(x_h) = \phi_i(L/2)^*$	$\phi_i(x_q) = \phi_i(L/4)^*$	$m_{ihh}/\mu L=1/[\phi_i^2(x_h)]$	$m_{iqh}/\mu L=1/[\phi_i(x_h) \;\; \phi_i(x_q)]$
I	1.00	1.588	0.863	0.397	0.731
II	2.76	0	1.441	00	∞
ш	5.40	1.406	1.363	0.506	0.521
IV	8.93	0	0.565	00	00
V	13.34	1.415	-0.520	0.500	-1.360

^{*}From References 14 and 15.

Equation 104 may be used to determine the template profile for the beam of this example. Small amounts of damping (large Q values) will affect the shape of the profile only near resonance as shown in Fig. 5² and will have little effect away from this frequency. This characteristic is also true near anti-resonances.

Mobility methods may also be used to predict the effect of making changes in the structure. Thus, addition of a concentrated mass at the midpoint of the fixed-end beam in this example will alter the shape of the response curve of Fig. 33. To illustrate this effect, assume that a weight of 100 lb is placed at the midpoint of the beam where excitation occurs. Mass and beam act in parallel, so impedances rather than mobilities must be added. Impedance of the mass is jmo, while impedance of the beam is found by taking the reciprocal of the combined mobility curve (solid) in Fig. 33. These two impedance curves, plotted on a velocity-impedance basis, are shown as dashed lines in Fig. 35. The resultant curve, which is shown as a solid line, is found by adding the dashed curves algebraically. Reference 10 discusses this procedure in detail and gives confirming experimental data.

Final article in this series will discuss methods for analyzing frames or structures, and beams which are mounted on flexible supports.

REFERENCES

This article is the sixth in a series by Austin H. Church on simplified vibration analysis. Previous articles and issues of Machine Design in which they appeared are:

1.	"Mobility and Impedance Concepts" February 18,	1960
2.	"Single-Degree-of-Freedom Systems" March 3,	1960
3.	"Two-Degree-of-Freedom Systems"	1960
4.	"Lumped Multiple-Mass Systems"	1960
5.	"Combination of Subsystems"April 14,	1960

Other references in this article are:

- R. E. D. Bishop—"The Analysis of Vibrating Systems Which Embody Beams in Flexure," Proc. of the Inst. of Mech. Engr. (British), Vol. 169, 1955, pp. 1031-1050.
- R. E. D. Bishop—"The Vibration of Frames," Proc. of the Inst. of Mech. Engr. (British), Vol. 170, 1956, pp. 955-968.
- W. J. Duncan—"Mechanical Admittances and Their Applications to Oscillation Problems," Aero. Research Council Reports and Memos. (British), No. 2000, 1947.
- R. Plunkett—"Semi-Graphical Method for Plotting Vibration Response Curves," Proc. of the 2nd U. S. National Congress of Applied Mechanics, ASME, June, 1954, pp. 121-126.
- R. Plunkett—"Measurement of Mobility." Journal of Applied Mechanics, September, 1954, pp. 250-256.
- J. P. Den Hartog—Mechanical Vibrations, McGraw-Hill Book Co. Inc., New York, 1956, p. 148.
- Jacobsen and Ayre—Engineering Vibrations, McGraw-Hill Book Co. Inc., New York, 1958, p. 482.
- S. Timoshenko and D. H. Young—Vibration Problems in Engineering, D. Van Nostrand Co. Inc., Princeton, N. J., 1955, p. 324.
- R. E. D. Bishop and D. C. Johnson—Vibration Analysis Tables, Cambridge University Press, New York, 1956.
- D. Young and R. P. Felgar—Tables of Characteristic Functions of a Beam, Engineering Research Series, No. 44, University of Texas, 1949.

Tips and Techniques

Selecting Components

Standard value components such as resistors, gears, or sheaves can be selected easily to fit a given ratio by using the sliderule. Set the index at the required ratio on the D scale. Set the hairline at a standard value on the D scale and read the required corresponding value for the other member of the pair on the C scale. Possible combinations can be rapidly considered, especially if tolerance limits are applied mentally.—Jesse Roth, New York, N. Y.

Pipe Diameters

Outside diameters of pipe, for layout purposes, can be approximated by adding 5/16 in. to the nominal pipe size. For sizes through 1 in. pipe, this method of approximation provides answers that are accurate to within a few hundredths of an inch. For pipe sizes from 1½ to 2 in., the error involved is still small—less than 0.1 in.—Claude Learn, Bendix Westinghouse Automotive Air Brake Co., Elyria, Ohio.

Looking for a guide to filter selection?

Here are application data on the most common . . .

Filter Materials

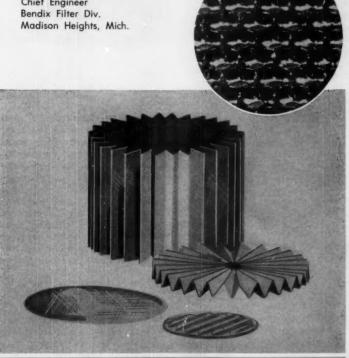
EW and more critical applications of fluid flow have greatly increased the types and forms of filter materials available.

The most common types of modern filtration materials are metallic mesh, sintered wound wire, sintered bronze, resin-impregnated cellulose fiber, and resin-bonded inorganic fiber. Each type can be adapted to many different application requirements when the material is fabricated into filter elements. Typical variations include end-cap materials, end-cap bonding, sealing materials, supporting structures, and filter-material configurations.

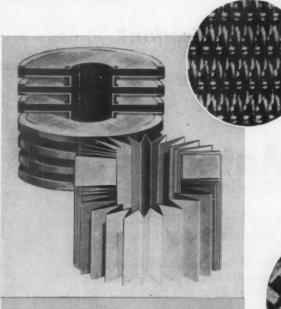
Although the filter element materials may be fabricated in different shapes, each of the materials is generally used for similar application requirements.

WALTER KASTEN

Chief Engineer Bendix Filter Div.

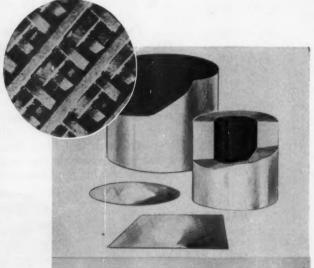


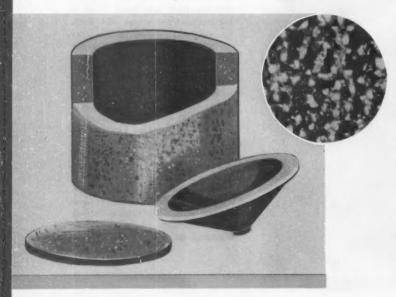
Stainless-steel wire-mesh filter is fabricated from woven-wire cloth. To prevent relative shifting or movement, all crossing wires are bonded by sintering. Cloth is then rolled to provide uniform pore size. Nominal pore-size ratings vary from 2 to 1000 microns, and operating temperature is continuous from -400 to +1500 F, depending on mesh material. Elements are supplied as pleated cylinders, pleated sheets, flat discs, pleated discs, and other variations. Thinwall construction, high strength, and corrosion resistance permit thorough cleaning without frequent replacement. Applications include lubricating oils, fuels, hydraulic oils, and gases.



Unsintered woven-wire cloth filters are fabricated from stainless steel, nickel, aluminum, brass, or monel. They have a high mechanical strength and can be cleaned for re-use. Nominal pore-size ratings are from 5 microns up. Operating range is continuous from -400 F to +1200 F, depending on filter media and bonding materials. Elements are fabricated as flat or pleated discs, pleated sheets, and pleated cylinders. They are employed to filter gases, fuels, oils, and chemical solutions.

Wound-wire mesh-type filter is fabricated by accurately controlled winding of a fine, flattened wire on a mandrel. Sintering in a controlled-atmosphere furnace bonds the crossing wires at contact points. This processing results in a seamless porous tube with diameters ranging from 3/32 to 12 in. Elements are generally supplied in cylindrical form, but can be made in flat sheets or conical form. Material is highly ductile and can be readily shaped by stamping, punching, rolling, or forming. Assembly methods include adhesive bonding, silver soldering, and welding. Filter elements are made from stainless steel, Inconel, N-155, nickel, copper, Hastelloy, L605, and Nichrome. Nominal pore-size ratings vary from 5 to 250 microns. Operating temperature is continuous from $-400 \, \mathrm{F}$ to $+1800 \, \mathrm{I}$ F, depending on wire material. Filters are re-usable and applications include hydraulic oils, fuels, liquid oxygen, fuming nitric acid, helium, and nitrogen.





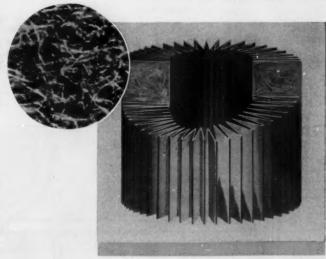
Sintered-bronze filter elements are a product of powder metallurgy and were developed as a low-cost metallic element. These elements are made by molding and sintering small spheres of bronze under high temperatures. Sintered filter elements of this type do not require separate end-caps; the closed end can be formed as part of the sintered mold and the inlet or outlet fitting can be bonded to the element during the sintering process. Sintered bronze filters can be partially cleaned for re-use. Those with larger pores and thinner wall sections are easier to clean than the finer grades with thicker wall sections.

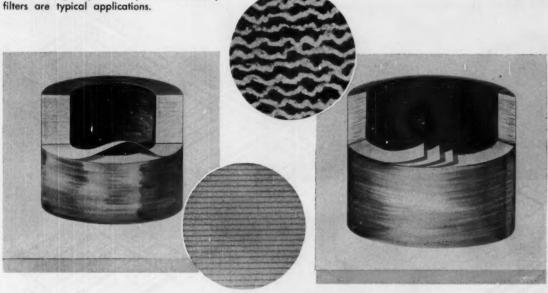
Nominally rated filtration is from 2 to 60 microns. Operating temperatures range continuously from $-350~\mathrm{F}$ to $+600~\mathrm{F}$. These filter elements can be molded into various shapes such as discs, cones, and cylinders. Typical applications include hydraulic systems, automotive fuel-tank filters and machine-tool

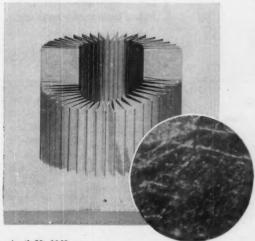
air lines.

Phenolic resin-impregnated cellulose filters are most common in pleated cylinder configuration. This type passes high flow and has a large dirt-holding capacity. Rated filtration is from 2 to 40 microns. Operating temperatures range is from $-65\ {\rm F}$ to $+275\ {\rm F}$. Typical applications include hydraulic systems, automotive air cleaners, lubricating oils, and fuels.

Punched cellulose washers, phenolic resin-impregnated and in a spring-loaded assembly, are effective devices for withstanding high pressure differentials and providing a fine, controlled filtration. Filters can be cleaned for re-use. Rated filtration is from ½ to 10 microns. Operating temperature is from -65 F to +275 F. Air instrumentation, fluid flow test stands, nitrogen gas, and petroleum-industry filters are typical applications.



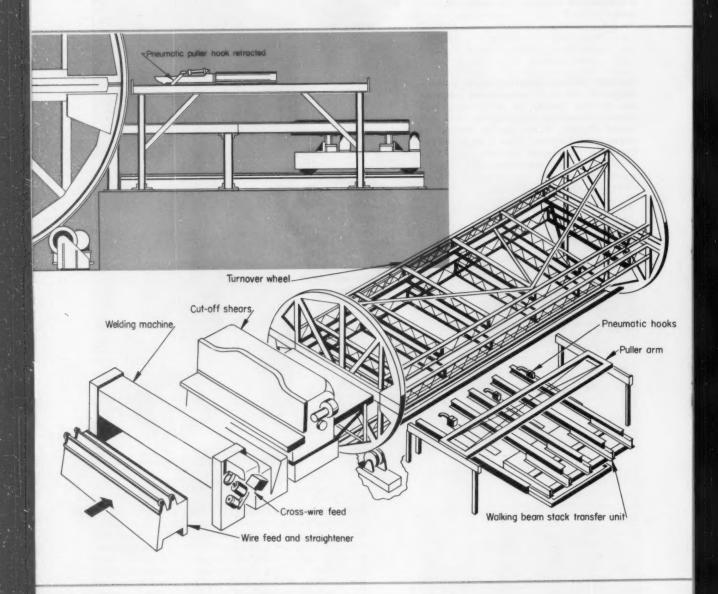




Resin-impregnated ribbons of cellulose helically wound into cylinders, provide a low-cost, noncorrosive filter. Forming a high-strength, self-supporting cylinder, this medium can be easily designed into many types of filters. In most cases, it requires no supporting hardware or end caps. Filtration rating is 40 microns. Operating temperature is from $-65\ F$ to $+275\ F$. It can be easily cleaned for re-use and is employed for hydraulic and pneumatic systems reservoirs, breathers, compressors, and pneumatic lines.

Inorganic fiber bonded into a sheet material is generally pleated in filter elements to provide a low-cost filter for use up to 400 F. Filtration ratings are 2, 5, and 10 microns. Although elements are disposable, pleats give them a high contaminant capacity for long service life. Applications include hydraulic and pneumatic systems, lubricating oils, and alcohol mixtures.

Giant Wire-Fabric Welder Positions Finished Mats

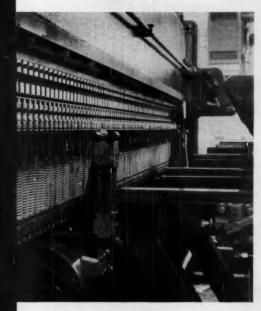


WIRE MATS ARE FLIPPED by a 20-ft diam turnover wheel. Mats, which are made for concrete reinforcement, can be stacked more compactly if every other one is turned over so that cross wires are nested. Puller arm running on rollers has pneumatically actuated hooks which pull the mats out of the wheel and stack them on an I-beam table. A walking-beam mechanism transfers the stack to the back of the table where it is bundled and loaded onto trucks. However, wire fencing, which is made in continuous lengths feeds through the inactive turnover wheel. Wire fabric making machine is a development of National Electric Welding Machines Co., Bay City, Mich.

for Compact Stacking



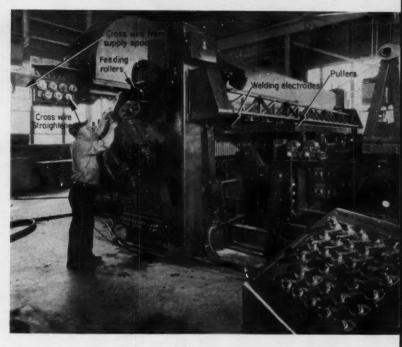
LONGITUDINAL WIRE IS FED into the welder from this wire straightener. Bushings, spaced 2 in. apart, feed the wire to straightening rolls hidden under the spaghetti-like oil lines.

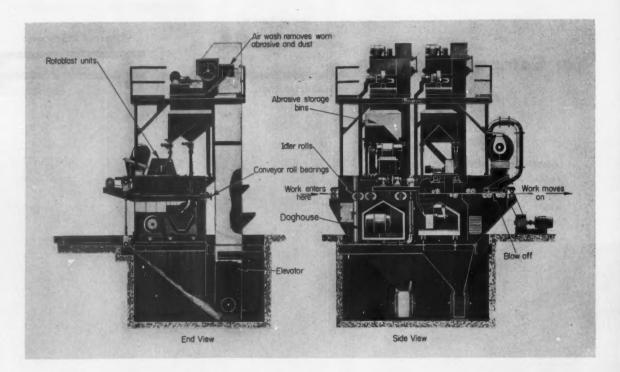


WELDING ELECTRODES repeat the spacing of the feed rollers. Pullers, at the right, are hooks that move between the electrodes and pull the cross wire. Welded mesh moves ahead one space. If the cross wire fails to weld, the pullers pull off the wire, but the mesh stays in place for another pass.

CROSS-FEED MECHANISM DELIVERS two cross wires at once, although only one is welded at a time. At a typical welding rate of 45 welding strokes per minute on 17-ft mesh, a single cross wire must travel 1500 fpm to be in position in time for the weld. Feeding two at once reduces this required speed to 750 fpm, resulting in less wear of equipment.

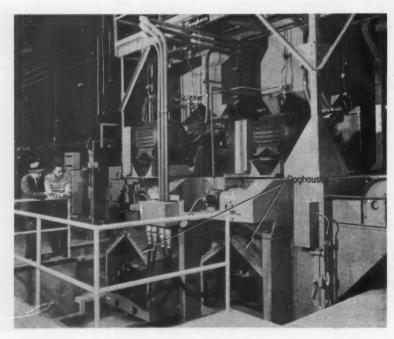






spent shot is recirculated and reconditioned for re-use in a continuous shot-blasting machine. Belt-bucket elevator returns shot to the top of the machine where an air bath removes debris, dust, and shot chips. Reconditioned shot falls into storage bins for re-use. Strip stock rides on rolls with external bearings that are protected from the abrasive atmosphere in the machine. Rolls can be removed and replaced by detaching a seal plate.

work moves through two parallel paths each served by two blast wheels—one for upper, and one for lower surface of stock. Blast wheels are isolated in "dog houses" that move in and out on rails to position wheels for most effective blast. Blow-off unit uses high-pressure air to sweep dust and spent shot into collecting bins as the stock leaves the machine.



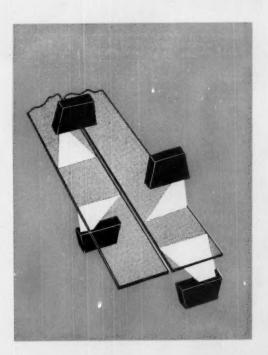
Shot blast equipment was developed by Pangborn Corp., Hagerstown, Md., and installed in Universal-Cyclops Steel Co. plant in Coshocton, Ohio.

Problem:

Shot Supply for Strip Descaling

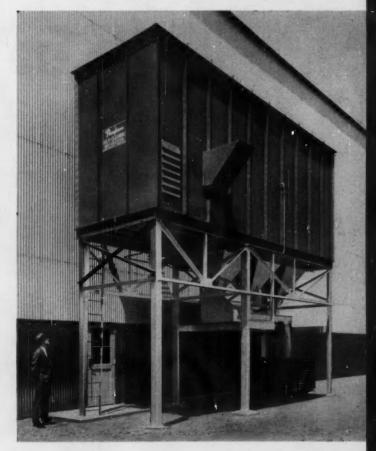
Answer:

Shot Elevator and Air Bath



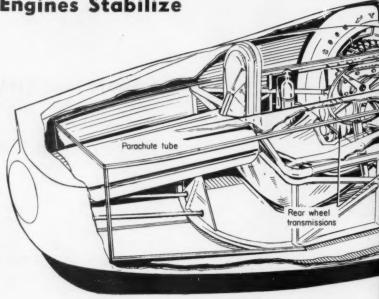
TWO STRIPS OF STOCK move through the machine independently at speeds up to 80 fpm as required by other processing equipment in the plant. Spray pattern of the shot thoroughly sweeps both sides of the stock.

DUST IS PIPED to an external cloth-bag dust collector that exhausts 2100 cfm. Sealing and dust-collection methods make the machine usable in the vicinity of other machines without special isolation.



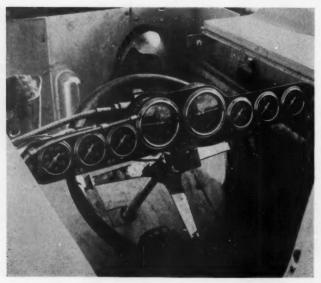
Counterrotating Engines Stabilize 300 plus mph Salt Flats Racer

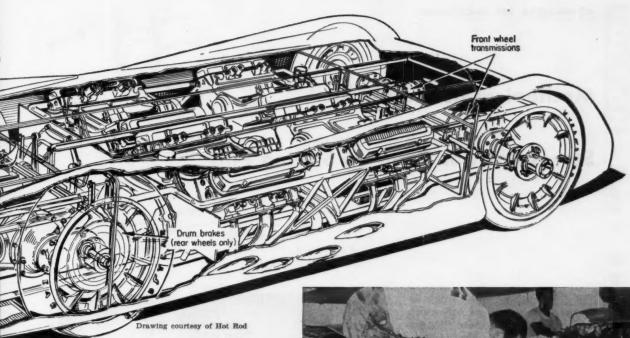
TORQUE DEVELOPED by 4-engine drive at speeds over 300 mph is balanced in a high-speed racer by reversing direction of rotation of two of the engines. This counter-rotating arrangement is possible because each 500-hp Pontiac engine drives a different wheel. Driver sits almost supine with his legs crooked over the rear axle.



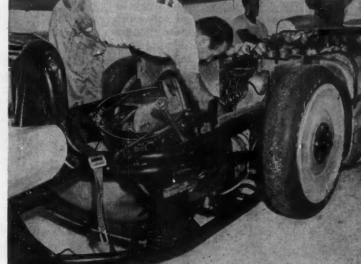


NOVEL CONTROL LAYOUT puts dash in front of steering wheel. Tachometers and oil gages are located to be read with barely a flick of the eyes from the road ahead. At 300 plus mph, limited steering freedom is adequate for any practical maneuvers. Foot pedals are throttle, right, and clutch, left. Brake controls are under the dash by the driver's right hand. There's one control for drum-type wheel brakes, and another that sets off an explosive charge to release two parachutes for drag brakes.

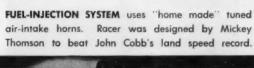


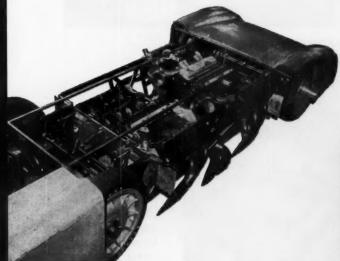


GEARSHIFT LEVERS ARE to the right of the steering column. They're coupled to shift four transmissions simultaneously—one for each wheel. At about 215 mph the driver pulls the first lever to put the four transmissions into second gear. At 310 mph he pulls the second lever to shift into high gear. Additional dials are on the floor of the cramped cockpit. Tires developed by Goodyear for this car have 0.020 in. rubber tread. Sidewalls have no rubber over fabric which is painted black. This tire has run safely on the Goodyear tire tester at speeds over 400 mph. Braking chutes are stowed in the tube behind the driver's seat.



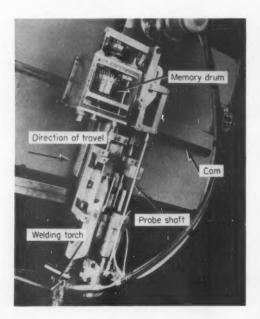
FORGED MAGNESIUM WHEELS have bolted-on spun aluminum hub caps over integral spoke-like bosses for maximum aerodynamic efficiency. Exhaust pipes—one for each bank of cylinders—port through side fairing of the car.



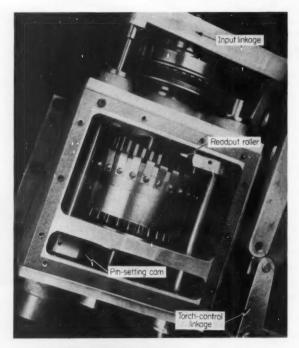


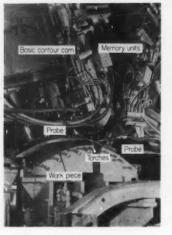
Mechanical Memory Drum Basic contour cam Stores Position Error on Sliding Pins Error Workpiece Probe Torch

PINS INDICATE VARIATIONS from basic contour of a part being welded on an automatic welder. Information about variations is picked up by motions of a four-bar linkage and transferred to a cam that pushes the pins into position and locks them there. Readout is accomplished by a roller that rides on top of the pins and positions a welding torch. After readout the pins are unlocked and pushed back to bottom position by a stationary cam. Drum rotation is synchronized with movement of the welder.



MOTION OF FOUR-BAR LINKAGE indicates part's variation from basic contour on master cam followed by carriage. A probe picks up actual contour of part, but leads torch by $3\frac{1}{2}$ in. Drum stores information until $3\frac{1}{2}$ in. is traversed, then it is mechanically "read out" to torch controls.





TWO WELDING ASSEMBLIES guided by
mechanical memories
are ready to weld
channel halves for
automobile cross
members. Mechanical
follower-tracer with
the mechanical memory drum was developed by Expert
Die and Tool Co. Inc.,
Detroit, Mich.

Table of gear combinations for

Planetary Gear Ratios

H. REED LANGDON

Senior Engineer Western Design Div. of U. S. Industries Inc. Santa Barbara, Calif.

SIMPLE planetary-gear systems, Fig. 1, can be readily adapted to a wide range of reduction-drive requirements in design. This article presents a table for quick selection of gear combinations to be used in building up the stages of simple planetary gearboxes to obtain specific reduction ratios. The table lists possible combinations of planetary gear sets for each ring gear size in the range from 50 to 126 teeth.

Basic arrangement for the gear combinations given

in the table is shown in Fig. 1. The sun gear is the input member and the planet carrier or arm is the output member. The ring gear is stationary. Gear ratio (input/output) for this simple planetary arrangement is (see Nomenclature)

$$m_G = \frac{N_E}{N_S} + 1 \tag{1}$$

Tooth combinations are based on two design relationships. In the moderate-ratio range, indicated by light-face type, this relationship is

$$N_R = 2N_P + N_S \tag{2}$$

These combinations are limited to sun and planet gears with a minimum of 12 teeth.

In the high-ratio range, indicated by bold-face type, the combinations are limited to sun gears with less than 12 teeth and planet gears with a minimum of 16 teeth. The number of teeth in the sun gear is reduced by one tooth to accommodate enlarged sizes of small gears and to prevent interference in

Nomenclature

 $d_0 = \text{Outside diameter of planet pinion}$

M = Number of planet pinions that will fit into gear set with equal chordal spacing

 $m_G = Gear ratio (input/output)$

 $N_P =$ Number of teeth in planet pinion

 $N_R =$ Number of teeth in ring gear

 N_{S} = Number of teeth in sun gear

P = Diametral pitch

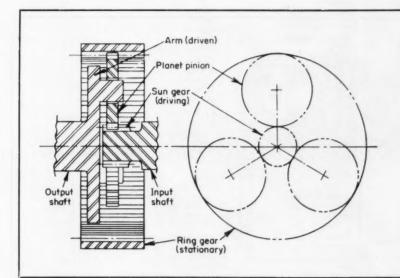


Fig. 1—Simple planetary gear system.

the ring-gear mesh. Basic relationship for these tooth combinations is*

$$N_E = 2N_P + (N_B + 1) (3)$$

The number, M, of planet pinions that will mesh into the gear assembly with equal chordal spacing is given in each listing. For all combinations, one planet pinion is possible and, thus, is not listed.

If a given number of planet pinions is to mesh with equal spacing in a planetary assembly, the necessary condition is

$$\frac{N_R + N_S}{M} = \text{Whole number} \tag{4}$$

Two sets of values are given for M in the table listings. Values not enclosed by parentheses represent numbers of equally spaced pinions that should fit on the assembly in the same plane without interference between the teeth of adjacent pinions. In some of these arrangements, however, the tips of the teeth of adjacent planets are so close that interference may result when manufacturing tolerances and running clearances are introduced. Individual gear combinations should be checked either by calculation or with an enlarged layout. For M planets to mesh in an assembly without interference,

$$d_0 < 2\cos\left(90 - \frac{180}{M}\right) \tag{5}$$

Values of *M* within parentheses represent numbers of pinions that cannot be assembled in the same plane.

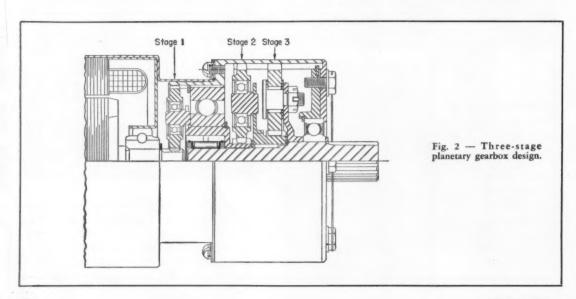
Design Example: A planetary gearbox is required to transmit $1\frac{1}{2}$ hp output at 34 rpm. Motor output speed is approximately 6500 rpm. Maximum outside diameter for gearbox is to be 4 in. Find the gear arrangement to provide the required reduction. The approximate total reduction ratio required

*E. Buckingham-Manual of Gear Design, Section 2, Machinery, New York, 1935, pp. 129-136. is 6500/34 or 191:1. Three stages, or passes, of reduction should satisfy this range of reduction. Various combinations of ring gears and diametral pitches can be utilized to meet this condition. Assume here that the input end of the gearbox must be reduced in diameter to facilitate final assembly. Two sizes of ring gears will be used. A small size gear will be used for the first stage, and a larger one for the second and third stages. Each stage will have three equally spaced planet pinions.

Because of the low torque load at input as well as certain structural design considerations, a small diametral pitch will be specified for the first stage.

For the reasons mentioned previously, assume that a ring gear pitch diameter of about 2.8 in. is desired. If a diametral pitch of 32 is selected, a ring gear with $N_R=89$ should satisfy this size requirement. In the first stage, a small number of teeth in the sun gear will simplify motor shaft design (the sun gear is integral with the shaft) and motor output-bearing selection. In the table at $N_R=89$, the gear combination for $N_S=13$ and $N_P=38$ has a gear ratio of $m_G=7.8461:1$. Also, M=3 is an acceptable number for this gear combination. Thus, this gear set will be the choice for the first stage.

For the second and third stages, larger ring gears (4 in. max diam) can be used. If P=20 and $N_R=74$, the ring gear pitch diameter is 74/20 or 3.7 in., which should be satisfactory. Gear combinations can now be selected from the table for these stages. Tooth combinations should be chosen to keep within the system envelope. For example, here are two gear combinations that would be suitable: For the second stage, $N_R=74$, $N_P=29$, $N_S=16$, and $M_G=5.6250$; for the third stage, $N_R=74$, $N_P=26$, $N_S=22$, and $M_G=4.3636$. Over-all gearbox ratio is 7.8451 (5.6250) (4.3636) = 192.5874 which is sufficiently close to 191 to give the desired output rpm. Fig. 2 shows the completed planetary gearbox.



Simple Planetary Gear Combinations

 $N_R = 50 \text{ to } 67$

V_P	N_B	m_{G}	M			ma	M	-		m_{θ}	M	-		m _G	
		$N_R =$	50	23	8	7.8750	3, (7) (5) 2, 4 2, (5, 7) 2, 3, 4, (6, 8)	16	27	3.185185	2	18	27	3.333333	2, 3, 5, 6
		- 1100		22	10	6.50	(5)	15	29	3.034482	2, 4, (8)	17	29	3.172413	2, 4
		8.142857	3	21	13	5.230769	2, 4	14	31	2.903225	2, 3, 5, 6	16	31	3.032258	2
0	9	6.555555		20	15	4.666666	2, (5, 7)	13	33	2.787878	2, 4	15	33	2.909090	2, 3, 4, 6, 8
		5.545454					0.0.4.40.00	12	35	2.685714	2	14	35	2.80	2, 7
9	12	5.166666	2									19	277	2.702702	
2	14	4 571429	2, 4, (8)				2 2, 4			$N_R =$	60	101.00	-		
			2, 2, (0)	17	21	3.619047	2, 4			IVE	00	12	39	2.615384	2, 3, 6
		4.1250	2, 3, (6)	16	23	3.391304	2, 3, 6	26	7	9.571428					
6	18	3.777777			25	3.20	2, 4, 5, (8)	25	9	7.666666	3			$N_R =$	64
0	20	3.50	2, 5, (7)	14	97	2 027027	0	24	11	6.45454		00		10 1400**	
1	22	3.272727	2, 3, 4, 6, (8)	12	20	2 904551	2 2 4 6 7	24	12	6.0	2. 3. (4. 6. 8)	28	,	10.192837	
1	24	3.083333	2	10	28	2.090001	2, 3, 2, 0, 1	23	14	5.285714	2	27		8.1111111	
		2.923076	2 4	12	31	2.774193	4	20		0.200111					
-	20	2.020010	-, -					22	16	4.750	2, 4	26	12	6.333333	
		NR =	F1			$N_R =$	56	21	18	4.333333	2, 4 2, 3, (6) 2, 4, 5, (8)	25	14	5.571428	2, 3, (6)
		IVR -	21	0.4	-	9.0	9 (8)	20	20	4.0	2, 4, 5, (8)	24	16	5.0	2, 4, (5, 8)
2	6	9.50	3				3, (1)	19	22	3.727272	2	23	18	4.555555	
		7.375				7.222222	(0)			3.50	2, 3, 4, 6, (7)	20	20	4.20	2 2 4 18
	10	6.10		22	11	6.090909									
	10	0.10	0 4 (0)	22	12	5.666666	2, (4)	17	26	3.307692	2			3.909090	
,	1.5	4.40	2, 4, (8) 2, 3, (6) 2, 4 2, 5, (7) 2, 3, 4, 6, (8)	21	14	5.0	2, (5, 7)	16	28	3.142857	2, 4, (8)	20	24	3.666666	2, 4, (8)
9	15	1.40	2, 3, (0)	20	16	4.50	2 3 4 (8 8)	15	30	3.0	2, 3, 5, 6	19	26	3.461538	2, 3, 5, 6
	17	4.0	2, 4	10	10	4 111111	2	14	32	2.8750	2, 4	18	28	3.285714	2, 4
	19	3.684210	2, 5, (7)	10	20	3.80	2 4	13	34	2.764705	2	17	30	3.133333	2
	21	3.428571	2, 3, 4, 6, (8)	10	20	2 545454	2 2 (4)	12	36	2.888888	2, 3, 4, 6, 8	16	32	3.0	2, 3, 4, 6, 6
	23	3.217301	2	17	24	3.040404	2, 3, (0)	14	00	2.00000	-, 0, -, 0, 0	15	34	2.882252	2. 7
	25	3.040	2, 4									10	02	2.002002	2, 1
				15	26	3.153846	2			$N_R =$	61	14	36	2.777777	2, 4, 5
	27	2.888888	2, 3, 6	14	28	3.0	2, 3, 4, 6, 7							2.684210	
							2	27	6	11.166666				2.60	2, 4, 8
		$N_R =$	59				0 4 9	26	8	8.0200	3				
		TAR	06	10	94	2.100	4, 1, 0	25	10	7.10					
	7	8.428571						24	13	5.692307	2			$N_R =$	65
	9	6.777777				$N_R =$	57	23	15	5.066666	2. 4				
		5.727272	3, (7)	0.00		10.70	0 (0)	-			0.0.700	29	6	11.833333	
		5.333333	0 1 (0)			10.50	3, (7)	22	17	4.588235	2, 3, (6) 2, 4, (5, 8) 2	28	8	9.1250	
		4.714285				8.1250	(5)	21	19	4.210526	2, 4, (5, 8)	27	10	7.50	3, (5)
	4.2	1.111100		23	10	6.70		20	21	3.904761	2	26	13	6.0	2, 3, (6)
,	16	4.250	2, 4	22	13	5.384615	2. (5, 7)	19	23	3.652173	2, 3, 4, (6, 7)	25	15	5.333333	2, 4, (5, 8)
	18	3.888888	2, 5, (7)	21	15	4.80	2, 3, 4, (6, 8)	18	25	3.440	2				
1	20	3.60	2, 3, 4, (6, 8)	20	17	4 252041	9	177	07	2 050050	2 4 (0)	24	17	4.823529	2
		3.363636	2	20	17	4.352941	2	17	27	3.259259	2, 4, (8)	23	19	4.421052	2, 3, 4, (6,
		3.166666	2 4	19	19	4.0	2, 4	16	29	3.103448	2, 3, 5, 6	22	21	4.095238	2
	~ 1	0.10000	A, A	18	21	3.714285	2, 3, (6)	15	31	2.967741	2, 4	21	23	3.826086	2, 4, (8)
3	26	3.0	2, 3, 6	17	23	3.478260	2 2, 4 2, 3, (6) 2, 4, 5, (8)	14	33	2.848484	2	20	25	3.60	2, 3, 5, (6)
2	28	2.857142	2, 4, 5, 8	16	25	3.280	2	13	35	2.742857	2, 3, 4, 6, 8				
				115	05	9 111111	2, 3, 4, 6, 7	10	27	0.040040	0.77			3.407407	
		A7						14	91	2.010010	4, 1			3.241379	
		IVR -	53												2, 3, 4, 6,
3	6	9.833333					2, 4, 8			$N_R =$	62			2.969696	
		7.6250		12	33	2.727272	2, 3, 5, 6					15	35	2.857142	2, 4, 5
	10	6.20	3, (7)					27	7	9.857142	3	14	97	2.756756	238
	12	5.076022	2, 3, (6)			Np =	58	26	9	7.888888		19	99	2 666666	2 4 9
						T A 30	00	25	11	6.636363				2.666666	
	15	4.533333	4	25	7	9.285714	(5)			6.166666	2	12	41	2.585365	4
	17	4.117647	2, 5, (7)	24	9	7.444444									
	19	3.789473					3	24	14	5.428571	2, 4			$N_R =$	66
		3.523809	2	23	12	5.833333	3 2, (5, 7) 2, 3, 4, (6, 8)	23	16	4.8750	2, 3, (6)				
		3.304247	2. 4	22	14	5.142857	2, 3, 4, (6, 8)	22	18	4.444444	2, 4, (5, 8)	29	7	10.428571	
			2, 3, 6	22		212280000	_, _, _, (0, 0)	21	20	4.1	2	28	9	8.333333	3, (5)
				de A	AU	1.0400	All	20	22	3.818181	2, 3, 4, (6, 7)	10.0	AA	1.0	(7)
	27	2.962962	2, 4, 5, (8)	20	18	4.222222	2, 4					27	12	6.50	2, 3, (6)
			2			3.90				3.583333					2, (4, 5, 8)
							2, 4, 5, (8)			3.384615					
		3.9	F4				2				2, 3, 5, 6			5.125	2
			54					16	30	3.066666	2, 4				2, 3, 4, (6,
	7	8.714285		16	26	3.230769	2, 3, 4, 6, (7)	15	32	2.93750					2
		7.0										22	22	4.0	2, 4, (8)
				14	30	2.933333	2, 4, 8	14	34	2.823529	2, 3, 4, 6, 8	0.4	0.4		
		5.909090		13	32	2.81250	2, 3, 5, 6	13	36	2.722222	2, 7				2, 3, 5, (6)
		5.50	2, 3, (6)	12	34	2.705882	2, 4	12	38	2.631578	2, 4, 5			3.538461	
,	14	4.857142	2, 4											3.357142	
	14	4.3750	2, (5, 7)			$N_R =$	50			No -	63				2, 3, 4, 6,
		4.00	2, 3, 4, (6, 8)			TAK -	05			TAK	03	17	32	3.06250	2, 7
		3.70		26	6	10.833333	(5)	28	6	11.50	(3)	10	24	2.941176	2 4 5
			2	25	8	8.3750				8.8750					
			2, 4	9.4	10	6.80	3			7.30				2.833333	
)	24	3.250	2, 3, (6)	22	12	5 539444	2 2 (4 6 9)			5.846153	2. (4)			2.736842	
	20	3 076022	2, 4, 5, (8)				2, 3, (4, 6, 8)					13	40	2.650	2
				22	15	4.933333	2	24	15	5.20	2, 3, (6)	12	42	2.571428	2, 3, 4, 6
		2.928571				4.470588		23	17	4.705882	2, 4, (5, 8)				
	30	2.80	2, 3, 4, 6, 7	20	10	4.105262	2 3 (6)	22	10	4.315799	2			31	CT
				20	2.0	3 900500	2, 3, (6)	25	91	4.0	2, 3, 4, (6, 7)			$N_R =$	01
		$N_R =$	55				2, 4, 5, (8)							12 160000	
				15	23		2	20	60	0.10010	2	Ott	-	-411-40000	
		10.166666			gram.	9 900	2, 3, 4, 6, (7)		CO.M.	9 500	9 4 (8)	9.0		9.3750	3 (8)

NP	Ns	ma	M	NP	Ńs	mg	M	NP	Ns	me	M	NP	N_8	ma	M
28	10	7.70	(7)	16	38	2.842105	2, 3, 4, 6			$N_R =$	74			10.6250	(5)
27	13	6.153846	2, (4, 5, 8)	15	40	2.750	2, 5	00	-	11 171400				8.70	3
26	15	5.466666	(7) 2, (4, 5, 8) 2 2, 3, 4, (6, 7)	14	42	2.666666	2, 4, 7, 8	33	9	9.222222	0			6.923076	2, 3, (5, 6)
25	17	4.941176	2, 3, 4, (6, 7)	13	46	2.521739	2, 3, 6	31	11	7.727273	(5)				
ALC: N	W-05.	T.OFOOTO	-	12	48	2.458333	2, 4	OT	14	1.100000	dia .			5.529411	
23	21	4.190476	2, 4					30	14	6.285714	2, (4)			5.052631 4.666666	2, 3, 4, (6, 8)
22	23	3.913043	2, 3, 5, (6)			$N_R =$	71	29	16	5.625	2, 3, (5, 6)				
21	25	3.680	2, 4 2, 3, 4, 6, (8) 2, 7 2, 4, 5 2, 3, 6 2, 4, 8 2, 3, 4, 6 2, 5	20		10 000000	(9)	28	18	5.111111	2, 3, (5, 6) 2, 4 2	26	25	4.080	2, 3, (6)
20	27	3.481481	2	31	8	0.8750	(1)	27	20	4.70	2				
19	29	3.310344	2, 3, 4, 6, (8)	30	10	8.10	3	26	22	4.363636	2, 3, 4, (6, 8)	25	27	3.851851	2, 4, (8)
18	31	3.161290	2, 7	29	13	6.461538	2, 3, (4, 6, 7)	25	24	4.083333	2, (7)	24	29	3.655172	2 2 4 6
17	25	2.030303	2, 4, 5	28	15	5.733333	2	24	26	3.846153	2, 4, 5	22	33	3.333333	2. 5
10	00	2.011200	2, 5, 0	27	17	5 176470	2 4 (8)	23	28	3.642857	2, 3, 6	21	35	3.20	2, 4, 7, (8)
15	37	2.810810	2, 4, 8	26	19	4.736842	2, 3, (5, 6)	22	30	3.466666	2, 4, (8)				0.0.0
14	39	2.717948	2	25	21	4.380952	2, 4	21	32	3.31250	2	20	37	3.081081	2, 3, 6
13	42	2.634146	2, 3, 4, 0	24	23	4.086956	2	20	34	3.176470	2, 3, 4, 6	19	41	2.972048	2, 2
12	23	2.008109	2, 3	23	25	3.840	2, 3, 4, (6, 8)	19	36	3.055555	2, 5	17	43	2.790697	2, 3, 4, 5, 6, 8
		Mn =	- 69	22	27	3.629629	2. (7)	18	38	2.947368	2, 5 2, 4, 7, 8 2, 3, 4, 6 2, 4	16	45	2.711111	2
		TAK	00	21	29	3.448275	2. 4. 5	17	40	2.850	2, 3, 4, 6		400	0.00000#	0.4
30	7	10.714285	3, (5)	20	31	3.290322	2, 3, 6	16	42	2.761904	2, 4	15	47	2.638297	2, 4
29	9	8.55555	(7)	19	33	3.151515	2, 4, (8)	15	44	2.681818	2	13	51	2.509803	2, 4, 8
28	11	7.181818	0 // 5 0	18	35	3.028571	2	14	46	2.608695	2, 3, 4, 5, 6, 8	12	53	2.452830	2, 5
27	1.2	5.657440	2, (1, 0, 8)	17	37	2.918918	2, 3, 4, 6	13	48	2.541666	2	~~	30		
41	12	0.001112	2, 5 68 3, (5) (7) 2, (4, 5, 8) 2 2, 3, 4, (6, 7)	16	39	2.820512	2, 5	12	50	2.480	2, 4			A7	79
26	16	5.250	2, 3, 4, (6, 7)	15	41	2.731707	2, 4, 7, 8							IVR -	- 10
25	18	4.777777	2 2, 4, (8)	14	43	2.651162	2, 3, 6					40.00	-		
24	20	4.40	2, 4, (8)	13	45	2.577777	2, 4	34	6	13.5	(3)	34	9	9.666666	3
00	24	2.090909	2, 3, 5, (8) 2, 4	12	47	2.510638	2			the last section and		33	11	8.090909	
								32	10	8.50	(5)	33	12	7.50	2, 3, (5, 6)
		3.615384						31	13	6.769230	(5) 2, (4, 8)	32	14	6.571428	2, (4)
20	28	3.428571	2, 3, 4, 6, (8)			$N_R =$	72	30	15	6.0	2, 3, (5, 6)	31	16	5.8750	2
19	30	3.266666	2, (7)	33	7	11.285714		20	17	5.411764	2, 4	30	18	5.333333	2, 3, 4, (6, 8)
17	34	3.1200	2, 3, 4, 6, (8) 2, (7) 2, 4, 5 2, 3, 6 2, 4, 8 2 2, 3, 4, 6 2, 5	31	9	9.0	3	28	19	4.947368	2	29	20	4.90	2, (7)
Ti	02	3.0	4, 3, 0	30	11	7.545454		27	21	4.571428	2, 3, 4, (6, 8)	28	22	4.545454	2, 4, (5)
16	36	2.888888	2, 4, 8	30	12	7.0	2, 5, (4, 6, 7)	26	23	4.260869	2, (7)	27	24	4.250	2, 3, (6)
15	38	2.789473	2	29	14	6.142857	2	25	25	4.0	2, 4, 5	26	26	4.0	2, 4, (8)
14	40	2.70	2, 3, 4, 6	28	16	5.50	2. 4. (8)	24	27	3.777777	2, 3, (6)	25	28	3.785714	2
19	22	2.019047	2, 5	27	18	5.0	2, 3, (5, 6)	23	29	3.586206	2, 4, (8)	24	30	3.60	2, 3, 4, 6
		$N_R =$	60	26	20	4.60	2, 4	22	31	3.419354	2, 3, (6) 2, 4, (8) 2 2, 3, 4, 6 2, 5				
				25	22	4.272727	2	21	33	3.272727	2, 3, 4, 6	22	34	3.294117	2, 4, (7, 8)
31	6	12.50	(3, 5)	24	24	4.0	2, 3, 4, (6, 8)	20	35	3.142857	2, 5	21	38	3.166666	2, 3, 6
30	8	9.6250	(7)	23	26	3.769230	2, (7)	19	37	3.027027	2, 4, 7, (8)	20	38	3.052631	2, 4
28	13	6 307602	2	22	28	3.571428	2, 4, 5	18	39	2.923076	2, 3, 6	19	40	2.950	2
27	15	5.60	2 3 (4 6 7)	21	30	3.40	2, 3, 6	17	41	2.829268	2, 4	18	42	2.857142	2, 3, 4, 5, 6, 8
			-, -, (-, -, -,	20	32	3.250	2, 4, (8)	16	43	2.744186	2	17	44	2.772727	2
26	17	5.058823	(7) 2 2, 3, (4, 6, 7) 2 2, 4, (8)	19	34	3.117647	2	15	45	2.666666	2, 3, 4, 5, 6, 8	16	46	2.695652	2, 4
24	21	4.031078	2, 4, (8) 2, 3, (5, 6)	18	36	3.0	2, 3, 4, 6 2, 5	14	47	2.595744	2	15	48	2.625	2, 3, 6, 7
23	23	4.0		17	38	2.894736	2, 5	13	49	2.530612	2, 4	14	50	2.560	2, 4
22	25	3.760	2	16	40	2.80	2, 4, 7, 8	12	51	2.470588	2, 3, 6, 7			2.50	
										37	. 70	12	54	2.44444	2, 3, 4, 6
20	20	9 970910	2, 3, 4, 6, (8)	14	44	2.636363	2, 4			$N_R =$. 10				
19	31	3 225806	2, (7) 2, 4, 5 2, 3, 6	13	46	2.565217	2	34	7	11.857142				$N_R =$	79
18	33	3.090909	2, 3, 6	12	48	2.50	2, 3, 4, 5, 6, 8	33	9	9.444444	(5)				
17	35	2.971428	2, 4, 8					32	11	7.909090	3	36	6	14.166666	9
10	27	9 004004	2, 4, 8 2 2, 3, 4, 6 2, 5 2, 4, 7, 8 2, 3, 6			$N_P =$	73	32	12	7.333333	2, (4, 8)	38	10	8.00	3
15	30	2 780230	2 3 4 8					31	14	0.428071	2, 3, (5, 6)	33	13	7.076923	2, (4)
14	41	2.682926	2. 5	33	6	13.100006		30	16	5.750	2, 4	32	15	6.266666	2
13	43	2.604651	2, 4, 7, 8	32	8	10.1250	3	29	18	5.222222	2				0 0 4 (0 0)
12	45	2.533333	2, 3, 6	31	10	8.30	0	28	20	4.80	2, 3, 4, (6, 8)	31	17	5.647058	2, 3, 4, (0, 8)
				20	15	5 888888	2 (4.8)	27	22	4.454545	2, (7)	30	19	0.107894	2 4 (5)
		N _P =	70	20	10	0.000000	A, (1, 0)	26	24	4.166666	2, 4, 5	29	21	4 434792	2, 2, (6)
0.5	-		400	28	17	5.294117	2, 3, (5, 6)	25	26	3.923076	2, 3, (6)	27	25	4.160	2, 4, (8)
31	7	TI.U	(7)	27	19	4.842106	2, 4	24	28	3.714285	2, 4, (8)				•
29	11	7.363636	3	26	21	4 179019	2 3 4 (4 8)	23	30	3.533333	2	26	27	3.925925	0 2 4 (0)
29	12	6.833333	2	24	25	3.920	2. (7)	22	32	3.3750	2, 3, 4, 6	25	29	3.724137	2, 3, 4, (6)
28	14	6.0	2, 3, (4, 6, 7)		-		-1 3.7	21	31	3.235294	2, 0	24	99	3 303030	2.4. (7.8)
ne	**	E 0872		23	27	3.703703	2, 4, 5	20	36	3.111111	2, 4, 7, (8)	23	25	3.257142	2, 3, 6
20	10	4 999999	2 4 (9)	22	29	3.017241	2, 3, 6	19	38	3.0	2, 3, 6		90	J	-, -, -
25	20	2.000000	2 3 (5 6)	21	32	3 212121	9	18	40	2.90	2, 4	21	37	3.135135	2, 4
24	22	4.181818	2. 4	10	35	3.085714	2, 3, 4, 6	17	42	2.809523	2 2 4 7 7 6	20	39	3.025641	2 2 4 5 4 5
23	24	3.916666	2	70	00	J. GOOTA'S	a, o, x, 0	16	44	2.727272	2, 3, 4, 5, 6, 8	19	41	2.926829	2, 3, 4, 5, 6, 8
00	0.4	0.000	0.0.1.10	18	37	2.972972	2, 5	15	46	2.652173	2	18	43	2.83/209	2 4
22	26	3.692307	2, 3, 4, (6, 8)	17	39	2.871794	2, 4, 7, 8	14	48	2.583333	2, 4	17	40	4. 100000	۵, ٦
21	28	3.30	2, (7)	16	41	2.780487	2, 3, 6	13	50	2.520	2, 3, 6, 7	16	47	2.680851	2, 3, 6, 7
10	32	3 18750	2 3 6	1.0	45	2 622222	4, 2	12	52	2.461538	2, 4	15	49	2.612244	2, 4, 8
18	34	3.058823	70 (7) 3 2 2, 3, (4, 6, 7) 2 2, 4, (8) 2, 3, (5, 6) 2, 4 2 2, 3, 4, (6, 8) 2, (7) 2, 4, 5 2, 3, 6 2, 4, (8)	4.2	10	w. 944444	-			N	77	14	51	2.549019	2, 5
	40.00		(0/	13	47	2.553191	2, 3, 4, 5, 6, 8			TAK	4.6	13	53	2.490566	2, 3, 4, 6
								-	-				-	0 4000-0	0

N	P N	s m_G	M	111-11	N _P N	$l_S m_G$	M	Λ	IP N	$V_S = m_G$	M	. 1	IP N	s mo	M
		N _R =	= 80		18 46	2.782608	2, 4, 8	3	0 2	5 4.40	2, (5)	11	5 53	2.526315	2, 3, 4, 6, 8
94					17 48	2.708333	2, 5	04		7 4 9 4 9 4 4	0 4 (7 0)	14	1 59	2.474576	2
36	9	9,899800	(3)		16 50	2.640	2, 3, 4, 6	21	3 2	3.931034	2, 4, (7, 8)	13	61	2.426229	2, 4
					15 52	2.576923	2, 4, 8	27	31	3.741935	2, (5) 3 2, 4, (7, 8) 4 2, 3, (6) 5 2, 4	12	63	2.380952	2, 3, 5, 6
34	12	7.666666	2, (4)		AT 01	2.015015	2, 4, 8 2, 3, 6 2, 4, 5, 7	26	3	3.575757	2				
33	14	6.714285	2		13 56	2.464285	2, 3, 6	20	5 30	3.428571	2, 3, 4, 5, 6, (8)			$N_R =$	
					12 08	2.413793	2, 4, 0, 7	24	31	3.297297	2 2, 4 2, 3, 6, 7 2, 4, 8	40	7	13.571428	(5)
31	18	5 444444	2 (7)			3.7	- 00	23	31	3.179487	2, 4	38	9	10.777777	
30	20	5.0	2, 4, (5)			$N_R =$	- 83	22	41	3.073170	2, 3, 6, 7	38	11	9.0	2 (4 %)
29	24	4.333333	2, 4, (8)		38 6	14.833333	4.883	21	48	2.976744	2, 3, 6, 7 2, 4, 8 2, 5 2, 3, 4, 6 2 2, 4, 8 2, 3, 6 2, 4, 5, 7	38	12	7.285714	2, 3, (6)
~0	00	4 050000	a, z, (d)		37 8	11.3750	(7)	20	100	2.000008	2, 0	01	1.2	0.00	0 (4 9)
27	26	4.076923	2 2 4 4	(8)	36 10	7 394615	2.3 (4.6	8) 19	47	2.808510	2, 3, 4, 6	36	16	6.50	2, (4, 8)
25	30	3.666666	2, 5, 4, ((0)	34 15	6.533333	2, 6, (4, 0,	17	51	2.734093	2 4 8	35	20	5.40	2, 3, 4, (6)
24	32	3.50	2, 4, (7,	8)	00 47	K googra	2 (4 5)	16	53	2.603773	2, 3, 6	33	22	5.0	2, (5)
23	34	3.352941	2, 3, 6		32 19	5.388421	2, 3, (6)	15	55	2.545454	2, 4, 5, 7	32	24	4.666666	2, 4, (7, 8)
22	36	3.222222	2. 4		31 21	4.952380	2, 4, (8)	14	57	2,491228	2	31	26	4.384615	2, 3, (6)
21	38	3.105263	2		30 23	4.608695	2	13	59	2.440677	2, 4, 5, 7 2 2, 3, 4, 6, 8 2	30	28	4.142857	2, 4
20	40	3.0	2, 3, 4, 5	, 6, 8	29 25	4.320	2, 3, 4, (6)	12	61	2.393442	2	29	30	3.933333	2
					28 27	4.074074	2, 5								
18	44	2.818181	2, 4			0.000000	0 4 47 03			$N_R =$	= 86	27	34	3.588235	2
17	46	2.739130	2, 3, 6, 7	- :	26 31	3.677419	2, 3, (6)	20	- N	13 988714	2, (7) 2, (4, 5) 2, 3, (6)	26	36	3.444444	2, 4
16	48	2.666666	2, 4, 8		25 33	3.515151	2, 4	38	9	10.555555	(5)	25	38	3.315789	2, 3, 6, (7)
14	52	2.539461	2, 5		ra 35	3.371428	2	37	11	8.818181	1-7	24	40	3.20	2, 2, (0)
13	54	2.481481	2, 3, 4, 6		37	3.243243	2, 3, 4, 5, 6,	(8) 37	12	8.166666	2, (7)	23	44	3.0	2, 3, 4, 6
10	Ro	2 400===	0 4 0	2	2 39	3.128205	2 4	36	14	7.142857	2, (4, 5)	22	**	0.040046	9
12	56	2.428571	2, 4, 8		0 42	2 920222	2, 3, 4, 5, 6, 2 2, 4 2, 3, 6, 7	35	16	6.3750	2, (4, 5) 2, 3, (6) 2, 4, (8) 2 2, 3, 4, (6)	21	46	2.913043	2 4 8
					.0 20	2.000202	2, 4, 8	34	18	5.777777	2, 4, (8)	20	50	2.760	2, 3, 6
		$N_R =$			0 47	0.745055	9. 8	33	20	5.30	2	18	52	2.692307	2, 4, 5, 7
37	6	14.50	(3)	1	7 49	2.693877	2, 3, 4, 6	32	22	4.909090	2 2, 3, 4, (6) 2, (5)	17	54	2.629629	2
36	8	11.1250	480	1	6 51	2.627450	2	31	24	4.083333	2, (5) 2, 4, (7, 8) 2, 3, (6) 2, 4	10	56	2.571428	2, 3, 4, 6, 8
35	10	9.10	(7)	1	5 53	2.566037	2, 4, 8	30	26	4.307692	2, 4, (7, 8)	15	58	2.517241	2
33	15	6.40	2.3.14.4	8. 8) 1	4 55	2.509090	2, 3, 6	29	28	4.071428	2, 3, (6)	14	60	2.466666	2, 4
00	10	5.20 5.20	2, 0, (1, 0	3	3 57	2.456140	2, 4, 5, 7	28	32	3.68750	2, 4	13	62	2.419354	2, 3, 5, 6
32	17	5.764705	2, (7)	1	2 59	2.406779	2, 4, 5, 7 2	26	34	3.529411	2 2, 3, 4, 5, 6, (8)	12	64	2.3750	2, 4, 8
30	21	4.857142	2, 3, (6)							3.388888				A* -	90
		4.521739				$N_R =$	84				2, 4			$N_{R} =$	
						19.0	(9)	23	40	3.150	2, 3, 6, 7	41		15.833333	
27	27	4.0	2, 3, 4, (6	3) 3	7 9	13.0 10.333333 8.636363	3	22	42	3.047619	2, 3, 6, 7 2, 4, (8) 2, 5	40		12.1250	
26	29	3.793103	2, 5	3	6 11	8.636363	(5)	21	44	2.954545	2, 5	39	10	9.90	2 3 (6)
25	31	3.612903	2, 4, (7, 8	3) 3	6 12	8.0	2, 3, (4, 6,	8) 20	46	2.869565	2, 3, 4, 6	38	15	6.933333	2, (4, 8)
24	33	3.454545	2, 3, 6	3	5 14	7.0	2, (7)	19	48	2.791666	2	31	AU	31000000	0
23	35	3.314285	2, 4	3	4 16	6.250	2, (4, 5)	18	50	2.720	2, 4, 8	36	17	6.235294	2 3 4 (6)
22	37	3.189189	2	3	3 18	5.666666	2, 3, (6)	17	52	2.553846	2, 5 2, 3, 4, 6 2 2, 4, 8 2, 5, 6 2, 4, 5, 7	35	21	5.238095	2, (5)
21	39	3.076923	2, 3, 4, 5, 6	3, (8)	2 20	5.2	2, 4, (8)	16	9.8	2.002002	2, 4, 5, 7 2 2, 3, 4, 6, 8 2 2, 4 87 (3)	33	23	4.869565	2, 4, (7, 8)
10	41	2.975609	2 4	3	1 22	4.818181	2 3 4 (8)	15	56	2.535714	2	32	25	4.560	2, 3, (6)
18	45	2.80	2, 3, 6, 7	3	0 24	1.0	4, 0, 1, (0)	14	58	2.482758	2, 3, 4, 6, 8	21	27	4.296296	2. 4
40	477	0.700404	0.4.0	2	9 26	4.230769	2, 5	13	62	2,387096	2. 4	30	29	4.068965	2
16	49	2.653061	2, 5	2	7 20	3.80	2, 3, (6)	1.0	-		-, -	29	31	3.870967	2, 3, 4, 5, (6, 8)
15	51	2.588235	2, 3, 4, 6	2	8 32	3.6250	2, 4			27	07	28	33	3.696969	2
14	53	2.528301	2	2	5 34	3.470588	2			NR =	8/	27	35	3.542857	2, 4
13	55	2.4727272	2, 4, 8		1 90	3 332322	2 2, 3, 4, 5, 6, (2	8) 40	6	15.50	(3)				
			2, 3, 6	2	F 30	3.333333	2, 0, 1, 0, 0, (39	8	11.8750	(5)	25	39	3,282051	2, 4, (8)
				25	2 40	3.10	2, 4	38	10	9.70	2, (4, 5) 2, 3, (6)	24	41	3.170731	2, 5
		$N_R =$	82	21	42	3.0	2, 3, 6, 7 2, 4, 8	37	13	6.80	2, (4, 5)	23	43	3.069767	2, 3, 1, 0
61.00				20	44	2.909090	2, 4, 8	40	40	0.00	-, 0, (0)	22	10	2.011111	
37	7 1	0.111111	(7)	10	46	2.826086	2, 5	35	17	6.117647	2, (4, 8) 2 2, 3, 4, (6) 2, (5) 2, 4, (7, 8)	21	47	2.893617	2, 4, 8
35	11	8.454545	3	18	48	2.750	2, 3, 4, 6	34	19	5.578947	2 2 4 (4)	20	49	2.816326	2, 3, 6
35	12	7.833333	2, (4)	17	50	2.680	2	32	23	4.782608	2, (5)	19	53	2.679245	2, 4, 0, 1
34	14	6.857142	2, 3, (4, 6,	, 8) 16	52	2.615384	2, 4, 8	31	25	4.480	2, 4, (7, 8)	17	55	2.618181	2, 3, 4, 6, 8
33	16	6.1250	2. (7)	18	54	2.555555	2, 3, 6	20	97	4 900000	2 2 (4)	40		0 501400	9
32	18	5.555555	2, 4, (5)	14	56	2.50	2, 4, 5, 7	20	20	4.0	2, 3, (6)	16	57	2.561403	2. 4
31	20	5.10	2, 3, (6)	13	58	2.448275	2	28	31	3.806451	2	14	61	2.459016	2, 3, 5, 6
30	22	4.727272	2, 4, (8)	12	60	2.40	2, 3, 4, 6, 8	27	33	3.636363	2, 3, (6) 2, 4 2 2, 3, 4, 5, 6, (8)	13	63	2.412698	2, 4, 8
29	24	4.4166666	2			3.7	05	28	35	3.485714	2	12	65	2.369230	2, 7
28	26	4.153846	2, 3, 4, (6))		NR =	60	25	37	3.351351	2. 4			**	00
27	28	3.928571	2, 5	39	6 1	5.166666	(7)	24	39	3.230769	2 2, 4 2, 3, 6, 7 2, 4, (8) 2, 5 2, 3, 4, 6			$N_B =$	90
26	30	3.733333	2, 4, (7, 8)	38	8 1	1.6250	(3)	23	41	3.121951	2, 4, (8)	41	7.1	3.857142	
25	32	3.56250	2, 3, 6	37	10	9.50	(5)	22	43	3.023255	2, 5	40	9 1	1.0	3
24	34	3.411764	2, 4	36	13	7.538461	2, (7)	21	45	2.933333	2, 3, 4, 6	39	11	9.181818	
		3.277777	2	35	15	o.666666	2, (4, 5)	20	47	2.851063	2	39	12	8.50	2, 3, (6)
23	36											38	14	7.428571	Z. (4, 8)
23 22	36	3.157894	2, 3, 4, 5, 6	6, 8 34	17	6.0	2, 3, (6)	19	49	2.775510	2, 4, 8				-, (-, -,
23 22 21	36 38 40	3.157894 3.050	2, 3, 4, 5, 6	6, 8 34 33	17	6.0 5.473684	2, 3, (6) 2, 4, (8)	19	49 51	2.775510 2.705882	2, 4, 8	37	16	6.6250	2
23 22 21 20	36 38 40 42	3.157894 3.050 2.952380	2, 3, 4, 5, 6 2 2, 4	6, 8 34 33 32	17 19 21	6.0 5.473684 5.047619	2, 3, (6) 2, 4, (8) 2	18 17	51 53	2.775510 2.705882 2.641509	2 2, 4, 8 2, 3, 6 2, 4, 5, 7	37 36	16 18	6.6250 6.0	2, 3, (4, 6)

NP	Na	m_{θ}	M	N_P	Ng	m_G	M	N_P	N_8	m_G	M	N_P	Ns	m_G	М
34	22	5.090909	2, 4, (7, 8) 2, 3, (6)	25	42	3.190476	2	17	60	2.566666	2, 7			$N_R =$	97
33	24	4.750	2, 3, (6)	24	44	3.090909	2, 4, (8)	16	64	2.516129	2, 3, 4, 6	45	6 1	17.166666	
32	26	4.461538	2, 4 2 2, 3, 4, 5, (6, 8) 2	23	46	3.0	2, 3, 6	2.0	04	0.101010		44	8 1	13.1250	(3, 5, 7)
31	28	4.214285	2 2 4 5 (0.0)	22	48	2.916666	2, 4, 5, 7	14	66	2,424242	2, 4, 5, 8	43		0.70	0 (8)
29	32	3.81250	2, 3, 1, 0, (0, 8)	20	52	2.769230	2. 3. 4. 6. 8	12	70	2.342857	2, 4	41		8.461538 7.466666	2, (4, 7, 8)
28	34	3.647058	2, 4	19	54	2.703703	2								
27	36	3.50	2, 3, 6, (7)	18	56	2.642857	2 2, 4 2, 3, 5, 6 2, 4, 8			$N_R =$	95			6.105263	2, 3, (6)
ma	-	0.000.00	2, 4, (8)	17	58	2.586206	2, 3, 5, 6	44	6	E 922222		38	21	5.619047	2
25	40	3.250	2, 5	16	60	2.533333	2, 4, 8	43	8	12.8750		37	23	5.217391	2, 3, 4, (5, 6, 8)
24	42	3.142857	2, 4, (8) 2, 5 2, 3, 4, 6	15	62	2.483870	2, 3, 5, 6 2, 4, 8 2, 7 2, 3, 4, 6 2, 4, 5, 8 93 (3)	42	10	19.50	3, (5, 7)	36	25	4.880	2
200	**	0.010101	2	12	UT	2.10100	2, 0, 1, 0	41	13	8.307692	2, 3, (4, 6)	35	27	4.592592	2, 4
22	46	2.956521	2, 4, 8 2, 3, 6	13	66	2.393939	2 4 5 8	40	10	7.333333	2, (5)	34	29	4.344827	2, 3, (6, 7)
		2.80	2, 4, 5, 7	2.00	90	2.002011	2, 2, 0, 0	39	17	6.588235	2, (4, 7, 8)	32	33	3.939393	2, 3, (0)
		2.730769	2			$N_R =$	93	38	21	5.523809	2, 3, (6)	31	35	3.771428	2, 3, 4, (6)
18	54	2.666666	2, 3, 4, 6, 8	43	B 1	16.50	(3)	36	23	5.130434	2	30	37	3.621621	2
17	56	2.607142	2	42	8 1	2.6250	(0)	35	25	4.80	2, 3, 4, (5, 6, 8)	29	39	3.487179	2, 4, (8)
16	58	2.551724	2, 4	41	10 1	0.30		34	27	4.518518	2	28	41	3.365853	2, 3, 6
10	60	2.50	2, 3, 5, 6	40	13	8.153846	2	33	29	4.275862	2, 4	27	43	3.255813	2, 4, 5, 7
13	64	2.406250	2, 7	39	10	7.20	2, 3, (4, 6)	32	31	4.064516	2, 3, (6, 7)	20	40	3.130333	2
12	66	2 363636	2 2 4 8	38	17	6.470588	2, (5)	30	35	3.714285	2, 4, (8)	25	47	3.063829	2, 3, 4, 6, 8
	40	2.000000	2, 0, 1, 0	37	19	5.894736	2, 4, (7, 8)	00	27	9 505505	0.04.0	23	51	2.901960	2. 4
		N _P =	91	35	23	5.043478	2. 4	29	39	8.435897	2, 3, 4, 6	22	53	2.830188	2, 3, 5, 6
			W.L.	34	25	4.720	2	27	41	3.317073	2, 4, (8)	21	55	2.763636	2, 4, 8
42	6	16.166666	9)	33	27	4.444444	2, 3, 4, (5, 6, 8)	26	43	3.209302	2, 3, 6	20	57	2.701754	2, 7
40	10	10.10	37	32	29	4.206896	2	25	45	3.111111	2, 4, 5, 7	19	59	2.644067	2, 3, 4, 6
39	13	8.0	2, (4, 8)	51	31	4.0	2, 4	24	47	3.021276	2	18	61	2.590163	2 4 5 9
38	15	7.066666	2	30	33	3.818181	2, 3, (6, 7)	23	49	2.938775	2, 3, 4, 6, 8	16	65	2.492307	2, 3, 6
37	17	6.352941	2, 3, (4, 6)	20	00	0.001112	2, 4, (0)	21	53	2.792452	2 4	15	07	0.447761	2.4
36	19	5.789473	2, (5)	28	37	3.513513	2, 5	20	55	2.727272	2, 3, 5, 6	14	69	2.405797	2, 4
35	21	5.333333	2, 4, (7, 8)	26	41	3.268292	2, 3, 4, 5	19	57	2 666666	2 4 8	13	71	2.366197	2, 3, 4, 6, 7, 8
33	25	4.640	2, 3, (6)	25	43	3.162790	2, 4, (8)	18	59	2.610169	2, 7	12	73	2.328767	2, 5
20	077	4 250250	0	24	45	3.066666	2, 3, 6	17	61	2.557377	2, 3, 4, 6				
31	29	4.137931	2.3.4.5.(6.8)	23	47	2.978723	2, 4, 5, 7	16	63	2.507936	2			$N_R =$	98
30	31	3.935483	2, 3, 4, 6, 8 2 2, 4 2, 3, 5, 6 2, 4, 8 2, 7 2, 3, 4, 6 91 3) 2, (4, 8) 2 2, 3, (4, 6) 2, (5) 2, 4, (7, 8) 2, 3, (6) 2, 4 2 2, 3, 4, 5, (6, 8) 2 2, 3, 4, 5, (6, 8) 2 2, 4, (7)	22	49	2.897959	2	13	00	2.401038	2, 4, 5, 8	45	7 1	15.0	(3 5 7)
29	33	3.757575	2 2, 4	21	51	2.823529	2, 3, 4, 6, 8 2 2, 4	14	67	2.417910	2, 3, 6	44	9 1	11.888888	(3, 0, 1)
28	35	3.60	2, 3, 6, (7)	19	55	2.690909	2, 4	12	71	2.376811	2, 4	43	11	9.909090	
27	37	3.459459	2, 4, (8)	18	57	2 631578	2 3 5 6			1.000020	-			9.166666	
26 25	39	3.333333	2, 5 2, 3, 4, 6 2	17	59	2.576771	2, 4, 8			No =	06	42			2, (4, 7, 8)
24	43	3.116279	2	16	61	2.524590	2, 7			TAK	30	41	16	7.1250	2, 3, (6)
			2, 4, 8	15	63	2.476190	2, 7 2, 3, 4, 6 2	44	9 1	14.714285	2 (5 9)	39	20	5.90	2, (4)
22	47	2.936170	2, 3, 6	14	60	2.1130769	2	42	11	9.727272	3, (0, 1)	38	22	5.454545	2, 3, 4, (5, 6, 8)
21	49	2.857142	2, 4, 5, 7	13	67	2.388059	1, 4, 5, 8	42	12	9.0	2, 3, (4, 6)	37	24	5.083333	2
								41	14	7.857142	2, 3, (4, 6) 2, (5)	36	26	4.769230	2, 4
19	55	2.716981	2, 3, 4, 6, 8			Mn =	04	40	16	7.0	2, (4, 7, 8)	35	28	4.50	2, 3, (6, 7)
		2.001010	2, 3, 4, 6, 8 2 2, 4 2, 3, 5, 6 2, 4, 8			TAK	34	39	18	6.333333	2, 3, (6)	34	30	4.266666	2, 4, (8)
17	57	2.596491	2, 4	43	7 1	4.428571		38	20	5.80	2, 4	32	34	3.882352	2, 3, 4, (6)
15	61	2.491803	2, 4, 8	41	11	9.545454	3, (5, 7)	36	24	5.0	2, 3, 4, (5, 6, 8)	91	20	9 700000	9
14	63	2.44444	2, 7	41	12	8.833333	2	95	28	4 602307	9	30	38	3.578947	2. 4. (8)
13	65	2.40	2, 3, 4, 6	40	14	7.714285	2, 3, (4, 6)	34	28	4.428571	2, 4	29	40	3.450	2, 3, 6
12	67	2.358208	2	39	16	6.8750	2, (5)	33	30	4.20	2, 3, (6, 7)	28	42	3.333333	2, 4, 5, (7)
				38	18	6.222222	2, (4, 7, 8)	32	32	4.0	2, 4, (8)	27	44	3.227272	2
		$N_R =$	92	37	20	5.70	2, 3, (6)	31	34	3.823529	2, 5	26	46	3.130435	2, 3, 4, 6, (8)
49	7	14 149957	(3)	35	24	4.916666	2	30	36	3.666666	2, 3, 4, 6	25	48	3.041666	2
41	9	11.222222	(3)	9.4	26	4 615384	2 3 4 (5 6 8)	29	38	3.526315	2 4 (8)	23	52	2.884615	2, 3, 5, 6
46	11	9.363636		33	28	4.357142	2, 3, 4, (0, 0, 0)	27	42	3.285714	2, 3, 6	22	54	2.814814	2, 4, 8
40	12	8.666666	2, (4, 8)	32	30	4.133333	2, 4	26	44	3.181818	2, 4, 5, 7	21	56	2.750	2. 7
39	14	7.571428	2	31	32	3.93750	2, 3, (6, 7)	25	46	3.086956	2	20	58	2.689655	2, 3, 4, 6
38	16	6.750	2, 3, (4, 6)	30	34	3.764705	2, 4, (8)	24	48	3.0	2, 3, 4, 6, 8	19	60	2.633333	2
37	18	5.60	2, (5)	29	36	3.611111	2, 5	23	50	2.920	2	18	62	2.580645	2, 4, 5, 8
35	22	5.181818	2, 3, (1, 8)	28	38	3.473684	2, 3, 4, 6	22	52	2.846153	2, 4	11	04	2.001200	4, 0, 0
34	24	4.833333	2, 4	26	42	3.238095	2, 4, (8)	21	02		2, 0, 0, 6	16	66	2.484848	2, 4
33	26	4.538461	2	25	44	3.136363	2, 3, 6	20	56	2.714285	2, 4, 8	15	70	2.40	2. 3. 4. H. 7. R
32	28	4.285714	2, 3, 4, 5, (6, 8)	24	46	3.043478	2, 4, 5, 7	18	60	2.60	2, 3, 4, 6	13	72	2.361111	2, 5
31	30	4.066666	2	23	48	2.958333	2	17	62	2.548387	2	12	74	2.324324	2, 4
30	32	3.8750	2, 4	22	50	2.880	2, 3, 4, 6, 8	16	64	2.50	2, 4, 5, 8			**	00
20		3.705882	2, 3, (0, 7)	21	52	2.807692	2	15	66	2.454545	2, 3, 6			$N_R =$	99
29	01			20	54										
29	36	3.555555	2. 3, 5, 6 2. 4, 8 2. 7 2. 3, 4, 6 2 (3) 2. (4, 8) 2 2. 3, (4, 6) 2. (5) 2. 4, (7, 8) 2. 3, (6) 2. 4 2 2, 3, (6, 7) 2, 4 2, 3, (6, 7) 2, 4, (8) 2, 4, (8) 2, 5, 2, 4, 6	20	54	2.740740	2, 4	14	68	2.411764	2, 4	46	6.1	7.50	(3, 5, 7)

	n.	00 10 100											P	LANETARY	GEAR RATIOS
N	IP I	$N_S m_G$	M	N	P N	s mg	M	N_{I}	N	s mg	M	N	P N	s mg	М
			2, (4, 7, 8)			6.941176			15	7.866666	2	47	10	11.50	(5)
	2 1		2, 3, (6)		19		2, 3, (4, 5, 6, 8)	43	17	7.058823	2, 3, (4, 5, 6, 8)			9.076923	
			2, (4)	39			2, 4				2	40		8.0	2, 3, (4, 5, 6, 8)
4		9 6.210526	2 2, 3, 4, (5, 6, 8)	38			2, 3, (6, 7)			5.904761				7.176470	_
		3 5.304347		37	27	4.740740	2, 4, (8)	40		5.478260	2, 3, (6, 7) 2, 4, (8)			6.526315	2, (4) 2, 3, (6, 7)
3	7 2	5 4.960	2, 4			4.482758									2, 4, (8)
3	6 2	7 4.666666	2, 3, (6, 7)	35	31	4.258064	2, 3, 4, (6)	38	27	4.814814	2, (5) 2, 3, 4, (6)	40		5.20	2, (5)
3			2, 4, (8)	34			2	-30	- 31	1.322389	4	39	27	4.888888	2, 3, 4, (6)
		1 4.193548			35		2, 4, (8)	35	33	4.121212	2, 4, (8)	38	29	4.620689	2
3:		3 4.0 5 3.828571	2, 3, 4, (6)		37		2, 3, (6)	34	35	3.942857	2, 3, (6)				2, 4, (8)
					39		2, 4, 5, (7)	33	37	3.783783	2, 4, 5, (7)				2, 3, (6)
3:			2, 4, (8) 2, 3, 6	-	43		2, 3, 4, 6, (8)	32	39	3.641025	2			4.0	2, 4, 5, (7)
29	-		2, 4, 5, (7)		45						2, 3, 4, 6, (8)			3.837837	
28				27	47	3.148936	2, 4			3.395348 3.288888				3.560975	2, 3, 4, 6, (8)
21	7 4	5 3.20	2, 3, 4, 6, (8)	26			2, 3, 5, 6							3.441860	
26	3 4	7 3.106382	2		51						2, 3, 5, 6 2, 4, (8)				2, 3, 5, 6
20	5 49		2, 4			2.905660					2, 7	29	47	3.234042	2, 4, (8)
			2, 3, 5, 6	23			2, 3, 4, 6				2, 3, 4, 6			3.142857	
22	3 53	3 2.867924 5 2.80	2, 4, 8			2.771929		24	55	2.872727	2				2, 3, 4, 6
			2, 7			2.711864 2.655737	2, 4, 5, 8	23	57	2.807017	2, 4, 5, 8			2.981132	
	5		2, 3, 4, 6				-	22	59	2.745762	2, 3, 6	25			2, 4, 5, 8
	61		2 2, 4, 5, 8	18	65	2.553846	2, 4	21	61	2.688524	2, 4	24	57	2.842105 2.779661	2, 3, 6
18			2, 3, 6	17	87	2 507462	7 3 4 6 7 9	20	63	2.634920	2, 3, 4, 6, 7, 8	23		2.779661	
17	6					2.463768									2, 3, 4, 6, 7, 8
16	67	2.477611	2	15	71	2.422535	2.4	18	67	2.537313	2, 5	20			
	69	2.434782	2, 3, 4, 6, 7, 8	14	73	2.383561	m; 0; 0	16	71	2.492753	2, 3, 6	19	67	2.567164	2.4
		2.394366	2, 5	13	75	2.346666	2, 4, 8	9.00	mo	9.410059	2 4 8			2.521739	
	73	2.356164	2, 4	12	77	2.311688	2	14	75	2.373333	2, 4, 5	17	71	2.478873	2, 4, 8
12	72	2.320	2. 3. 6					13	77	2.337662	2, 3, 4, 5, 6			2.438356	
						$N_R =$	192			2.393797		15	75	2.40	2, 3, 4, 5, 6
		$N_R =$												2.363636	
46	7	15.285714				15.571428				$N_R =$	104			2.329113	
45		12.111111	3	45		12.333333 10.272727	3	48	7	15.857142	(3)	12	31	2.296296	2, 3, 6
		10.090909		45		9.50	2, 3, (6)	47		13.555555					
			2, (4, 7, 8) 2, 3, (6)				2, (4)	46	11	10.454545				$N_R =$	106
				43	16	7.3750	2	46	12	9.666666	2, (4)	40	7	16.142857	
42			2, (4)	42			2, 3, (4, 5, 6, 8)	45	14	8.428571	2	48	9	12.777777	(5)
40			2, 3, (4, 5, 6, 8)	41		6.10	2			7.50	2, 3, (4, 5, 6, 8)			10.636363	
	22			40		5.636363				6.777777				9.833333	
38	24	5.166666	2, 4			5.250	2, 3, (6, 7)			6.20 5.727272	2, (4) 2, 3, (6, 7)	46	14	8.571428	2, 3, (4, 5, 6, 8)
37	26	4.846153	2, 3, (6, 7)			4.923076					2, 4, (8)			7.6250	2
36			2, 4, (8)	37 36		4.642857	2, (5) 2, 3, 4, (6)	39	26	5.0	2, (5)			6.888888	
35			-, -				2, 3, 4, (0)				2, 3, 4, (6)			6.30 5.818181	2, 3, (6, 7)
34			2, 3, 4, (6)				2, 4, (8)			4.466666				5.416666	
				33	36	3.833333	2, 3, (6)			4.250	2, 4, (8)				2, 3, 4, (6)
32		3.777777	2, 4, (8)	32	38	3.684210	2, 3, (6) 2, 4, 5, (7)	35	34	4.058823	2, 3, (6)			4.785714	
30	40	3 50	2 4 5 (7)	91	10	3.330	2				2, 4, 5, (7)	38	30	4.533333	2, 4, (8)
29	42	3.380952	2	30	42	3.428571	2, 3, 4, 6, (8)	33	38	3.736842	2	37	32	4.31250	2, 3, (6)
28	44	3.272727	2, 3, 4, 6, (8)	29	44	3.318181	2	32	40	3.60	2, 3, 4, 6, (8)	36	34	4.117647	2, 4, 5, (7)
27	46	3.173913	2	28	46	3.217391	2, 4	30	44	3.363636	2, 4	35	36	3.944444	2
26	48	3.083333	2, 4	27	48	3.1250	2, 3, 5, 6	20	40	2 260060	9356	34	38	3.789473	2, 3, 4, 6, (8)
25	50	3.0	2, 3, 5, 6	25	52	2.961538	2. 7	28	48	3.166666	2, 4, (8)	33	40	3.650	2 4
24	52	2.923076	2, 4, 8	24	54	2.888888	2, 3, 4, 6	27	50	3.080	2, 7	31	44	3.409090	2, 3, 5, 6
43	01	2.001801	4, 1	22	56	2 821429	9	26	52	3.0	2, 3, 4, 6	20	40	0.001015	0 4 (0)
22	56	2.785714	2, 3, 4, 6	22	58	2.758620	2, 4, 5, 8	25	54	2.925925	2	20	48	3 208333	2, 4, (8)
20	86	2.724137	2 4 5 8	21	60	2.70	2, 3, 6	24	56	2.857142	2, 4, 5, 8	28	50	3.120	2. 3. 4. 6
19	62	2.612900	2, 3, 6	20	62	2.645161	2, 4	23	58	2.793103	2, 3, 6	27	52	3.083461	2
18	64	2.56250	2, 4	19	64	2.593750	2	22	60	2.733333	2, 4	26	54	2.962962	2, 4, 5, 8
17	66	2.515151	2	18	66	2.545454	2, 3, 4, 6, 7, 8	20	64	2.6250	2, 3, 4, 6, 7, 8	25	56	2.892857	2, 3, 6
16	68	2.470588	2, 3, 4, 6, 7, 8	17	68	2.50	2, 5	4.0	00	0 686966	0.5	24	58	2.827586	2, 4
15	70	2.428571	2, 5	16	70	2.457142	2, 4	19	68	2.529411	2, 3	23	60	2.766666	2
14	72	2.388888	2, 4	14	74	2.378378	2, 4, 8	17	70	2.485714	2, 3, 6	22	62	2.709677	2, 3, 4, 6, 7, 8
13	74	2.351351	2, 3, 6	46	20	0.0404	0	16	72	2.44444	2, 4, 8	21	-01	2.000200	2. 0
12	76	2.315789	2, 4, 8	13	76	2.342105	2 3 4 5 4	15	74	2.405405	2	20	66	2.606060	2, 4
				1.4	10	2.00(092	2, 3, 2, 3, 6	14	76	2.368421	2, 3, 4, 5, 6	19	70	2.514285	2, 4, 8
		$N_R =$	101			3.7	100	13	78	2.333333	2, 7	17	72	2.472222	2
						NR =	103	12	80	2.30	2, 4, 8	16	74	2.432432	2, 3, 4, 5, 6
42	6	17,833333													
47 46	6	17.833333 13.6250		48	6 1	8.166666				87 -	10"	15	76	2.394736	2, 7
47 46 45	6 8 10	17.833333 13.6250 11.10	3	48 47	6 1 8 1	18.166666 13.8750	(3)			$N_R =$	105	15 14	76 78	2.394736 2.358974	2, 7 2, 4, 8
47 46 45 44	6 8 10 13	17.833333 13.6250 11.10 8.769230	2 2, 3, 4, 6, (8) 2 2, 4, 2, 3, 5, 6 2, 4, 8 2, 7 2, 3, 4, 6, 2 2, 4, 5, 8 2, 3, 6 2, 4, 5 2, 4 2, 3, 4, 6, 7, 8 2, 3, 6 2, 4, 8 101 3 2, 3, (6) 2, (4)	48 47 46	6 1 8 1 10 1	18.166666 13.8750 11.30	(3)	49	6 1	$N_R = 18.50$	105	15 14 13	76 78 80	2.394736 2.358974 2.3250	2, 7 2, 4, 8 2, 3, 6

NP	Na	m_{G}	M	N_P	Ns	m_G	M	N_P	Ns	m_{θ}	M	N_P	Ns	m_{G}	M
		N _R =	107	17	74	2.459459	2, 7	25	60	2.833333	2, 5	36	40	3.80	2, 4, (8)
				16	76	2.421052	2, 4, 8	24	62	2.774193	2, 4	35	42	3.666666	2, (7)
50	6 1	18.833333		15	78	2.384615	2, 7 2, 4, 8 2, 3, 6 2, 4, 5	23	64	2.718750	2, 5 2, 4 2, 3, 6	34	44	3.545454	2, 3, 4, 6
49	8 1	14.3750	(5) 3 2, 3, (4, 5, 6, 8) 2 2, (4)	14	80	2.350	2, 4, 5	22	66	2.666666	2, 4, 8	33	46	3.434782	2
47	13	0.220760	3 2 (4 5 6 0)	13	82	2.317075	2	21	68	2.617647	2	32	48	3.333333	2, 4, 5, (8)
46	15	8.133333	2, 3, (1, 0, 0, 3)	12	84	2.285714	2, 3, 4, 6, 8	20	70	2.571428	2, 3, 4, 5, 6	31	50	3.240	2, 3, 6
45	4.00							19	72	2.527777	2, 7	20	54	3.103040	2
44	17	7.294117	2, (4) 2, 3, (6, 7)			$N_R =$	109	18	74	2.480480	2, 4, 8	20	0.2	3.012012	
43	21	6.095238	2, (4) 2, 3, (6, 7) 2, (4, 8) 2, (5) 2, 3, 4, (6) 2 2, 4, (8) 2, 3, (6) 2 4, 5, (7)					17	76	2.447368	2, 3, 6	28	56	3.0	2, 3, 4, 6, 7, 8
42	23	5.652173	2, (5)	51	6	19.166666	(8)	16	78	2.410256	2, 4	27	58	2.931034	2, 3
41	25	5.280	2, 3, 4, (6)	50	8	14.6250	(3)	15	80	2.3750	2, 5	26	62	2.806451	2. 3. 6
40	27	4 963963	'0	49	13	9.384615	2	13	94	2.311103	2, 3, 2, 0, 6	24	64	2.750	2, 4, 8
39	29	4.689655	2 4 (8)	47	15	8.266666	2. (4)	10	9.0	0 070000	2 4 7			0.000000	0
38	31	4.451612	2, 3, (6)				0.0.10.00	12	00	2.219009	4, 3, 1	23	66	2.696969	2, 3, 4, 5, 6
:37	.33	4.242424	2, 3, (6) 2, 4, 5, (7)	46	17	7.411764	2, 3, (6, 7)					21	70	2.60	2, 7
36	35	4.057142		44	21	6 190476	2, (2, 8)			$N_R =$	111	20	72	2.555555	2, 4, 8
35	37	3.891891	2 3 4 (8 8)	43	23	5.739130	2, 3, 4, (6)					19	74	2.513513	2, 3, 6
34	39	3.743589	2	42	25	5.360	2	52	6	19.50	(3)	18	76	2.473684	2, 4
33	41	3.609756	2, 4	41	07	E 027027	0.4 (8)	51	10	14.8750	(7)	17	78	2.435897	2, 5
32	43	3.488372	2, 3, 5, 6	40	20	4 758620	2, 3, (6)	49	13	9.538461	2 (4)	16	80	2.40	2, 3, 4, 6, 8
31	45	3.377777	2, 4, (8)	39	31	4.516129	2, 4, (5, 7)	40	20	0.0003102	2, (2)	15	82	2.365853	2 4 7
30	47	3.276595	2, 7	38	33	4.303030	2	48	15	8.40	2, 3, (6, 7)	14	84	2.333333	£, Z, (
29	49	3.183673	2, 3, 4, 6	37	35	4.114285	2, 3, 4, (6, 8)	47	17	8 949105	2, (4, 8)	13	86	2.302325	2, 3, 6
28	51	3.098039	2	20	27	2 048045	9	48	23	6 995714	2 3 (4 8)	12	88	2.272727	2, 4, 5, 8
27	53	3.018867	2, 4, 5, 8	35	39	3.794871	2. 4	44	23	5.826086	2				
26	55	2.945454	2, 4, 5, (7) 2, 3, 4, (6, 8) 2, 4 2, 3, 5, 6 2, 4, (8) 2, 7 2, 3, 4, 6 2, 3, 4, 6 2, 3, 4, 6, 7, 8 2, 3, 4, 6, 7, 8 2, 4 2, 3, 4, 6, 7, 8 2, 4 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 3, 6 2, 7 2, 4, 8 2, 5	34	41	3.658536	2, 3, 5, 6	44	-0		0 4 450			$N_R =$	113
25	57	2.877192	2, 4	33	43	3.534883	2, 4, (8)	43	25	5.440	2, 4, (8)				(W)
24	59	2.813559	2	32	45	3.422222	2, (7)	41	27	4 927598	2, 3, (6)	53	6	19.833333	(7)
23	61	2.754098	2, 3, 4, 6, 7, 8	31	47	3 319148	2, 3, 4, 6	40	31	4.580645	2	52	8	10.120	3
22	63	2.698412	2, 5	30	49	3.224489	2	39	33	4.363636	2, 3, 4, (6, 8)	50	13	9.692307	2, 3, (6, 7)
21	65	2.646153	2, 4	29	51	3.137254	2, 4, 5, (8)	00			0	50	10	0.002001	0 44 0
20	67	2.597014	2, 3, 6	28	53	3.056603	2, 3, 6	38	35	4.171428	2 4	49	15	8.533333	2, (4, 8)
19	69	2.550724	2, 4, 8	27	55	2.981818	2, 4	26	39	3.846153	2, 3, 5, (6)	48	17	0.047368	2. 3. (4. 6)
18	71	2.507042	2	26	57	2 912280	2	35	41	3.707317	2, 4, (8)	47	23	6.921365	2
17	73	2.465753	2, 3, 4, 5, 6	25	59	2.847457	2, 3, 4, 6, 7, 8	34	43	3.581395	2, (7)	45	23	5.913043	2, 4, (8)
10	15	2.426666	2, 7	24	61	2.786885	2, 5	22	45	2 400088	2246	40			0 9 (8)
15	77	2.389610	2, 4, 8	23	63	2.730158	2, 4	32	47	3.361702	2	44	25	5.520	2, 4, (5, 7)
14	79	2.354430	2, 3, 6	22	65	2.676923	2, 3, 6	31	49	3.265306	2, 4, 5, (8)	43	20	4 896551	2
13	81	2.320987	12, 4	21	67	2.626865	2. 4. 8	30	51	3.176470	2, 3, 6	41	31	4.645161	2, 3, 4, (6, 8)
12	83	2.289156	2, 5	20	69	2.579710	2	29	53	3.094339	2, 4	40	23	4.424242	2
				19	71	2.535211	2, 3, 4, 5, 6	28	rsrs.	2 019191	2			4 000571	2 4
		$N_R =$	108	18	73	2.493150	2, 7	27	57	2.947368	2, 3, 4, 6, 7, 8	39	30	4.054054	2, 3, 5, (6)
30.00			= 108 (5) (3) (7) 2, 3, (4, 5, 6, 8) 5 2 2, (4) 2, 3, (6, 7) 2, (4, 8)	17	75	2.453333	2 2, 3, 4, 5, 6 2, 7 2, 4, 8	26	59	2.881355	2, 5	27	39	3.897435	2, 4, (8)
50	7	16.428571	(3)	16	77	2.415584	2, 3, 6	25	61	2.819672	2, 4	36	41	3.756097	2, (7)
49	9	13.0 10.818181	(3)	15	79	2.379746	2, 4	24	63	2.761904	2, 3, 6	35	43	3.627906	2, 3, 4, 6
		10.818181	(7)	14	81	2.345679	2, 5	23	65	2.707692	2, 4, 8	94	4.5	3.511111	2
		10.0	2, 3, (4, 5, 6, 8)	13	83	2.313253	2, 3, 4, 6, 8	22	67	2.656716	2	33	47	3.404255	2, 4, 5, (8)
		8.714288	5 2	12	80	2.282352	2	21	69	2.608695	2, 3, 4, 5, 6	32	49	3.306122	2, 3, 6
		7.750	2, (4)			**	110	20	71	2.563380	2, 7	31	51	3.215686	2, 4
44	20	6.40	2, 3, (6, 7)			$N_R =$	110	19	73	2.520547	2, 4, 8	30	53	3.132075	2
	-	0120	2, (2, 0)	63	2	16.714288	(3)	18	75	2.480	2, 3, 6	29	55	3.054545	2, 3, 4, 6, 7, 8
43	22	5.909090	0 2, (5)	50	-	13.222222	(7)	17	77	2.441558	2, 4	28	57	2.982456	2, 5
41	24	5.50	2, (4, 8) 2, (5) 2, 3, 4, (6) 8 2 2 2, 4, (8)	49	11	11.0		16	79	2.405063	2, 5	27	59	2.915254	2, 4
40	29	4.85714	5 2 2 2, 4, (8)	49	12	2 10.166666	2 2, (4)	15	81	2.370370	2, 3, 4, 6, 8	26	61	2.852459	2, 3, 6
	-		-, -, (0)	48	1.4	8.857147	2. (4)		00	-1001010	-	20	90	2.190000	2, 2, 0
20		4	2, 3, (6) 2, 4, 5, (7) 0 2	47	16	7.8750	2, 3, (6, 7)	1.3	85	2.305882	2, 4, 7	24	65	2.738461	2 2, 3, 4, 5, 6
20	32	4.3750	2, 4, 5, (7)	46	18	7.111111	2, (4, 8)	12	87	2.275862	2, 3, 6	23	67	7 2.686567	2, 3, 4, 5, 6
36	36	4.17647	0 2	45	20	6.50	2, (5)					22	66	2.637681	2, 7
		3.84210	2, 3, 4, (6, 8) 5 2	44	22	6.0	2, 3, 4, (6)			NR =	= 112	21	71	2.591549	2, 4, 8
			-	10	-	* 0.000000						20	73	3 2.04/940	2, 3, 0
-			-, -	42	20	5.230769	2, 4, (8)	52	7	17.0	(7)	19	72	2.506666	2, 4
33	42	3.57142	8 2, 3, 5, 6	41	. 2	4.92857	1 2, 3, (6)	51	. 8	13.44444		18	77	2.467532	2, 5
21	44	3.45454	2, 4 8 2, 3, 5, 6 5 2, 4, (8) 6 2, (7) 2, 3, 4, 6	40	30	4.66666	3 2, 4, (5, 7)	54	11	11.181818	3	17	75	2.430379	2, 3, 4, 6, 8
30	4.0	3.250	2, (7)	39	3:	4.43750	2	40	14	9.0	2 3 (8 7)	16	81	2.395061	2 4 7
29	50	3.160	2, 3, 4, 6	38	3	4.23529	2, 3, 4, (6, 8)	41	19	9.0	2, 0, (0, 1)	15	82	2.361440	2, 7, 1
-	-			37	3	8 4.055556	5 2 3 2, 4 2, 3, 5, (6)	48	16	8.0	2, (4, 8)	14	88	5 2.329411	2, 3, 6
- 28	52	3.07692	3 2, 4, 5, 8	36	3	3.894730	3 2, 4	47	18	7.22222	2, (5)	13	87	7 2.298850	2, 4, 5, 8
20	04	2 020==	2, 3, 6	35	4	3.750	2, 3, 5, (6)	40	20	6.000000	2, 3, (2, 0)	12	86	2.269662	2
25	5.0	2.86204	1 2, 4	34	4	3.51904	2, 4, (8)	44	24	5.68666	2, 4, (8)				
24	60	2.80	234670	33	4.	2 0.00	2, (7)	44	- 41		-, -, (0)			$N_R =$	= 114
-	-			32	40	3.39130	2, 3, 4, 6	43	26	5.307692	2, 3, (6)				
23	62	2.74193	5 2, 5	31	4	3.291660	3 2	42	28	5.0 4.790000	2, 4, (5, 7)	53	1	17.285714	(3)
22	64	2.68750	2, 3, 4, 6, 7, 8 5 2, 5 2, 4 3 2, 3, 6	30	50	3.20	2, 4, 5, (8)	41	30	4.733333	2 3 4 /0 0	52	-	13.666666	(5)
21	00	2 50000	3 . 2, 3, 6 5 2, 4, 8	29	5:	3.115384	2, 3, 5		-						2, 3, (6, 7)
10	70	2.54295													2, 0, (0, 1)
				27	56	3 2.964285	2	38	36	4.111111	2, 4				
		2.50	2, 3, 4, 6	26	58	2.896551	2, 3, 4, 6, 7, 8	37	38	3.947368	2, 3, 5, (6)	49	16	8.1250	2, (0)

N_P	N ₈	m _G	M	N_P	Ns	m_{θ}	M	N_P	Ns	me	M	N	N _E	m _G	M
			2, 3, (4, 6)			2.385542		31	55	3.127272	2, 4	48	23	6.173913	2
		6.70	2	15	85	2.352941	2, 4, 5, 8	30	57	3.052631	2 2 8	47	25	5.760	2, 3, 4, (6, 8)
		6.181818		14	87	2.321839	2				2, 4, 8	46	27	5.407407	2
45	24	5.750 2	, 3, (6)				2, 3, 4, 6	28		2.918032				5.103448	
44	26	5.384615	2, 4, (5, 7)			2.263736		27			2, 3, 4, 5, 6				2, 3, (5, 6)
43	28	5.071428						26		2.80	2, 7				2, 4, (8)
42	30	4.80	2, 3, 4, (6, 8)			$N_R =$	116	28	47	2.746268	2 4 8	42	35	4.40	2, (7)
	32	4.56250	2			14% -	110			2.695652					2, 3, 4, (6)
40	34	4.352941	2, 4	54	7 1	7.571428	(3)							4.051282	
39	36	4.166666	2, 3, 5, (6)			3.888888		22	73	2.602739	2, 4 2, 5	39			2, 4, 5, (8)
		4.0	2, 4, (8)	52	11 1	1.545454				2.560	2, 3, 4, 6, 8	38			2, 3, (8)
37	40	3.850	2, (7)				2, (4, 8)					37	45	3.644444	2, 4
36	.42	3.714285		51	14	9.285714	2, (5)	20	77	2.519480	2, 4, 7	36	47	3.531914	2
35	44	3.590909	2	50	16	8.25	2, 3, (4, 6)	19	79	2.481012	2, 4, 7	35	49	3.428571	2, 3, 4, 6, (7, 8)
94	40	9 479960	2, 4, 5, (8)				2	18	81	2.444444	2, 3, 5, 6	34	51	3.333333	2, 5
		3.3750	2, 3, 6	48	20	6.80	2, (4, 8)	17	83	2.376470	2, 4, 0	33	53	3.245283	2, 4
		3.280	2, 4				2, 3, (6)	16	80	2.3/04/0	4	32	55	3.163636	2, 3, 6
31		3.192307		46	24	5.833333	2, 4, (5, 7)	15	87	2.344827	2, 3, 4, 6	21	87	3.087719	2 4 8
30	54	3 111111	2, 3, 4, 6, 7, (8)		-	0.00000	-, -, (0, 1)	14	89	2.314606	2			3.016949	
				45	26	5.461538	2	13	91	2.285714	2, 4, 5, 8				2, 3, 4, 5, 6
		3.035714		44	28	5.142857	2, 3, 4, (6, 8)	12	93	2.258064	2, 3, 6, 7			2.888888	
		2.965517				4.866666						27		2.830769	
		2.90	2, 3, 6			4.6250	2, 4			M	119				
		2.838709					2, 3, 5, (6)			$N_R =$				2.776119	
		2.781250					2, 4, (8)			17.857142				2.724637	
24	.66	2.727272	2, 3, 4, 5, 6				2, (7)	54	9 1	14.111111				2.676056	
23	68	2.676470	2, 7		40		2, 3, 4, (6)	53	11 1	11.727272	3				2, 3, 4, 6, 8
22	70	2.628571	2, 4, 8				2	53	12 1	10.833333	2, (5)			2.586666	
		2.583333		36	44	3.636363	2, 4, 5, (8)	52	14	9.428571	2, 3, (4, 6)	21	77	2.545454	2, 4, 7
20	74	2.540540	2, 4	35	46	3.521739	2 2 6	51	16	8.3750	2			2.506329	
19	76	2.50	2, 5	34	48	3.418888	2, 3, 6				2. (4, 8)				2, 4, 5, 8
			2, 3, 4, 6, 8	33	50	3 320	2			6.90	2, 3, (6)	18	83	2.433734	2
17		2.4250	2, 3, 4, 0, 8				2, 3, 4, 6, 7, (8)		-		2, (4, 5, 7)	17	85	2.40	2, 3, 4, 6
		2.390243		31	54	3.148148	2, 0, 2, 0, 1, (0)				2	16	87	2.367816	2
15	84	2.357142	2, 3, 6											2.337078	
				30	56	3.071428	2, 4	46	26	5.538461	2, 3, 4, (6, 8)				2, 3, 5, 6, 7
14		2.325581		29	58	3.0	2, 3, 6 2, 4, 8 2	45	28	5.214285	2		-	2.279569	
				28	60	2.933333	2, 4, 8			4.933333				2.252631	
12	90	2.266666	2, 3, 4, 6	21	62	2.870987	2				2, 3, (5, 6)				
				26	04	2.81250	2, 3, 4, 5, 6	42	34	4.470088	2, 4, (8)				
		$N_R =$	115	25			2, 7			4.277777				$N_R =$	120
		2476	110			2.705882					2, 3, 4, (6)	80		18.142857	
54	6 :	20.166666				2.657142				3.950	2			14.333333	(9)
53	8	15.3750	(3)			2.611111					2, 4, 5, (8)			11.909090	(3)
		12.50	(5)	21	74	2.567567	2, 5	37	44	3.681818	2, 3, 6			11.0	2, 3, (4, 6)
51	13	9.846153	2, (4, 8)	20	76	2.526315	2, 3, 4, 6, 8	36	46	3.565217	2, 4			9.571428	
50	15	8.666666	2, (5)	19	78	2.497179	2	35	48	3.458333	2				
49	17	7.764705	2, 3, (4, 6)	18		2.450	2, 4, 7			3.360	2, 3, 4, 6, (7, 8)			8.50	2, (4, 8)
		7.052631					2, 3, 6				2, 5				2, 3, (6)
47		6.476190		16	84	2.380952	2, 4, 5, 8	32	54	3.185185	2, 4		20		2, (4, 5, 7)
	23		2, 3, (6)	15	86	2.348837	2	21	56	3.107142	2, 3, 6			6.454545	
	25	5.60	2, 4, (5, 7)			2.318181				3.034482		48	24	6.0	2, 3, (4, 6, 8)
44	ore					2.288888					2	47	26	5.615384	2
		5.259259	2, 3, 4, (6, 8)			2.260869		28	62	2.903225	2, 3, 4, 5, 6, 8	46	28	5.285714	2, 4
							_, _, _			2.843750		45			2, 3, (5, 6)
		4.709677				27	117				0.4			4.750	2, 4, (8)
			2, 3, 5, (6)			$N_R =$	11/			2.787878		43	34	4.529411	2, (7)
				55	6 2	0.50	(3)			2.735294	0 1 0	42	36	4.333333	2, 3, 4, (6)
39	37	4.108108	2, 4, (8)							2.685714					
38	39	3.948717	2, (7) 2, 3, 4, (6) 2, 4, 5, (8) 2, 3, 6 2, 4 2 2, 3, 4, 6, 7, (8) 2, 5	53	10 1	3.70	(0)	23	72	2.535555	2 3 4 4	40	40	4.0	2, 4, 5, (8)
37	41	3.804878	2, 3, 4, (6)	52	13 1	0.0	2. (5)	22	14	2.091091	4, 0, 2, 0	39	42	3.857142	2, 3, (6)
36	43	3.674418	2	51	15	8.80	2, 3, (4, 6)	21	76	2.552631	2	38	44	3.727272	2, 4
35	45	3.555555	2, 4, 5, (8)	KO	17	7 889980	0	20	78	2.512820	2, 4, 7, 8	-			
34	47	3.446808	2, 3, 6	40	10	7 157904	2 (4 8)	19	80	2.4750	2, 3, 6	37	46	3.608695	2
33	49	3.346938	2, 4	40	21	8 571499	2 3 (8)	18	82	2.439024	2, 4, 5	36	48	3.50	2, 3, 4, 6, (7, 8)
32	51	3.254901	2	47	23	0.011420	2 (4 5 7)	17	84	2.404761	2	35	50	3.40	2, 5
31	53	3.169811	2, 3, 4, 6, 7, (8)	48	25	5.680	2	16	86	2.372093	2, 3, 4, 6, 8	34	52	3.307692	2, 4
30	55	3.090909	2, 5	*0	40	,,000	-	15	88	2.340909	2	33	04	3.222222	2, 3, 6
-		0.045		45	27	5.333333	2, 3, 4, (8, 8)	14	90	2.311111	2, 4	32	56	3.142857	2, 4, (8)
29	57	3.017543	2, 4	44	29 1	5.034482	2	13	92	2.282608	2, 3, 5, 6, 7	31	58	3.068965	2
28	59	2.949152	2, 5, 4, 6, 7, (8) 2, 4 2, 3, 6 2, 4, 8	43	31	1.774193	2, 4	12	94	2.255319	2, 4, 8	30	60	3.0	2, 3, 4, 5, 6
27	61	2.885245	2, 4, 8	42	33	4.545454	2, 3, (5, 6)					29	62	2.935483	2, 7
26	63	2.825396	2 2, 3, 4, 5, 6	41	35	1.342857	2, 4, (8)					28	64	2.8750	2, 4, 8
			2, 3, 4, 5, 6	40	37	182102	2, (7)			$N_R = 1$	119				
		2.716417	0 77	40	01 1	1.102102	2, (()				440	27	66	2.818181	2, 3, 6
23	69	2.666666	2, 4, 8	38	41	3.853652	2	56	9 7	K 97KA	(3) 2, 3, (4, 6)	26	70	2.714205	2 5
22	71	2.619718	2, 3, 6	37	43	3.720930	2. 4. 5. (8)	54	10 1	2.90	(3)	20	72	2 666666	23488
21	73	2.575342	2, 4	36	45	3.60	2. 3. 6	52	13 1	0.153846	2, 3, (4, 6)	22	74	2 621621	2, 0, 1, 0, 0
20	75	2.533333	2, 5	-		14	-, 0, 0	59	15	8.933333	2	40	1.4	041041	-
				35	47	3.489361	2, 4	0.6	20	O: 040000	U 12/20	22	76	2.578947	2, 7
		2 493506	2 3 4 6 8	34	49 3	3.387755	2	5.1	17	8.0	2, (4, 8)	21	78	2.538461	2 2 6
19	77	0.455000	2, 0, 1, 0, 0	0.4				0.1		010	-,				2, 0, 0
19	77	2.455696	2, 5 2, 3, 4, 6, 8 2 2, 4, 7	33	51	3.294117	2, 3, 4, 6, 7, (8)	50	19	7.263157	2, 3, (6)	20	80	2.50	2, 4, 5, 8

NP	Na	mg	M	N_P	Na	m_{θ}	M	N_P	Ns	m_{θ}	M	NP	Ns	m_{θ}	M
18	84	2.428571	2, 3, 4, 6	41	40	4.050	2, 3, (6)	14	95	2.294736	2	37	51	3.450980	2, 4, (8)
20				40				13	97	2.268041	2, 4, 5	36	53	3.358490	2
17		2.395348			44	3.772727	2	12	99	2.242424	2, 3, 6	35	55	3.272727	2, 3, 4, 5, 6
16		2.363636					0 0 4 0 (7 0)					34	57	3.192982	2, 7
15			2, 3, 5, 6, 7			3.652173	2, 3, 4, 6, (7, 8)			$N_R =$	124	33	59	3.118644	2, 4, (8)
14	92	2.304347		37 36	50	3.440	2, 4	58	7	18.714285		32	61	3.049180	2, 3, 6
13	94	2.276595	12		52		2, 3, 6	57		14.777777	(7)	31	63	2.984126	2, 4
12	96	2.250	2, 3, 4, 6, 8		54	3.259259	2, 4, (8)			12.272727		30	65	2.923076	2, 5
				-				56		11.333333	2, (4, 8)	29	67	2.865671	2, 3, 4, 6, 8
		A7 -	101		56	3.178571		55	14	9.857142	2, 3, (6)	28	69	2.811594	2
		$N_R =$	121		58 60	3.103448	2, 3, 4, 5, 6	54	16	8.750	2. (4, 5, 7)	27	71	2.760563	2, 4, 7
57	6	21.166666		31	62	2.967741	2, 7	53	18	7.888888	2, (4, 5, 1)	26	73	2.712328	2, 3, 6
56		16.1250	(3)	29	64	2.906250	2, 3, 6	52	20	7.20	2, 3, (4, 6, 8)	25	75	2.666666	2, 4, 5, 8
33		13.10						51	22	6.636363	2	24	77	2.623376	2
54	13	10.307692	2			2.848484	2, 4	50	24	6.166666	2, (4)	23	79	2.582278	2, 3, 4, 6
53	15	9.066666	2, (4, 8)		68	2.794117		40	00				81	2.543209	2
		0.448048	0 0 (0)	26	70	2.742857	2, 3, 4, 6, 8	49	26 28	5.769230 5.428571		21	83	2.506024	2, 4, 8
52			2, 3, (6)		72 74	2.694444	2, 4, 7	47	30	5.133333	2, (7)	20	85	2.470588	2, 3, 5, 6, 7
51	19	6.761904	2, (4, 5, 7)			2.010010	4, 4, 4	46		4.8750	2, 3, 4, (6)	10	07	0.400004	
49	23		2, 3, (4, 6, 8)		76		2, 3, 5, 6		34	4.647058		19	87	2.436781 2.404494	2, 4
48		5.840	2, 3, (4, 5, 5)		78	2.564102	2, 4, 8					17	91	2.373626	2, 3, 4, 6, 8
***	20	01010	-			2.5250	2	44	36		2, 4, 5, (8)	16	93	2.344086	2
47	27	5.481481	2, 4				2, 3, 4, 6	43	38	4.263157		15	95	2.315789	2, 4, 5
46			2, 3, (5, 6)	19	84	2.452380	2	42	40	4.10 3.952380	2, 4				
45	31		2, 4, (8)		86	2.418604		41	44	3.952380	2, 3, 4, 6, (7, 8)	14		2.288659	2, 3, 6
44		4.666666		17	88	1.386363	2, 3, 5, 6, 7	20	22	0.010101	4, 0, 1, 0, (1, 0)	13	99	2.262626	2, 4, 7, 8
43	35	4.457142	2, 3, 4, (6)		90	2.355555	2, 4	39	46	3.695652	2, 5	14	101	2.237623	2
42	37	4.270270	2	15		2.326086	2		48	3.583333	2, 4				
41	39		2, 4, 5, (8)	14	94	2.297872	2, 3, 4, 6, 8	37	50	3.480	2, 3, 6			$N_R =$	126
40	41		2, 3, (6)	13	96	2.270833	2	36	52	3.384615					
39	43	3.813953				2.244897		35	54	3.296296	2	59	7	19.0	(7)
38	45	3.688888	2					34	56	3.214285	2, 3, 4, 5, 6	58	9	15.0	(3, 5)
						87	100	33	58	3.137931		57	11	12.454545	
37			2, 3, 4, 6, (7, 8)			$N_R =$	123	32	60	3.066666	2, 4, 8	57	12	11.50	2, 3, (6)
36	49	3.469387					400	31	62	3.0	2, 3, 6	56	14	10.0	2, (4, 5, 7)
35	51	3.372549	2, 4	58 57		21.50 16.3750	(3)	30	64	2.93750	2, 4	55	16	8.875 2	
34	53 55	3.283018 3.20	2, 3, 6 2, 4, (8)			13.30	(7)	29	66	2.878787	2, 5	54	18	8.0	2, 3, (4, 6, 8)
00	90	3.20	2, 2, (0)	55			2, (4, 8)	28	68	2.823529	2, 3, 4, 6, 8	53	20	7.30	2
32	57	3.122807	2	54		9.20	2, 3, (6)	27	70	2.771428	2	52	22	6.727272	2, (4)
31	59	3.050847	2, 3, 4, 5, 6	53	17	8.235294	2, (4, 5, 7)	26	72	2.722222	2, 4, 7	51	24	6.25	2, 3, (5, 6)
30	61	2.983606	2, 7	52	19	7.473684	2	25	74	2.675675	2, 3, 6	50	26	5.846153	2, 4, (8)
29	63	2.920634		51	21		2, 3, (4, 6, 8)	24	76	2.631578	2, 4, 5, 8	49	28	5.50	2, (7)
28	65	2.861538	2, 3, 6	50	23	6.347826	2	23	78	2.589743		48	30	5.20	2, 3, 4, (6)
27	67	2.805970	2, 4	49	25	5.920	2, 4	22	80	2.550	2, 3, 4, 6	47		4.93750	2
26	69	2.753623	2, 5	48	27		2, 3, (5, 6)	21	82	2.512195	2	46	34	4.705882	2, 4, (5, 8)
25	71	2.704225		47			2, 4, (8)	20	84	2.476190	2, 4, 8	45	36	4.50	
24	73	2.657534		46	31	4.967741		19	86	2.441860	2, 3, 5, 6, 7	44	38	4.315789	2, 3, (6)
23	75	2.613333	2, 4, 7	45	33	4.727272	2, 3, 4, (6)	18		2.409090		43	40	4.150	2
								17	90	2.377777		42	42	4.0	2, 3, 4, (6, 7, 8
22	77	2.571428		44		4.514285		16	92	2.347826	2, 3, 4, 6, 8	41	44	3.863636	2, 5
21	79	2.531645	2, 4, 5, 8	43			2, 4, 5, (8)	15	94	2,319148	2	40	40	0.700400	
20 19	81	2.493827	2 2, 3, 4, 6	42	39	4.103846	2, 3, (6)	14	0.0	2.291666	9 4 8	40 39	46	3.739130 3.6250	2, 4
18	85	2.423529	2, 3, 4, 0	40		3.860465				2.265306		38	50	3.520	2, 3, 6
10	00	a. 140040	-	40	20	0.000100	-			2.240	2, 4, 7, 8	37		3.423076	2, 4, (8)
17	87	2.390804	2, 4, 8	39	45	3.733333	2, 3, 4, 6, (7, 8)				-, -, -, -				2, 3, 4, 5, 6
16	89	2.359550	2, 3, 5, 6, 7	38	47	3.617021	2, 5								
		2.329670	2, 4	37	49	3.510204	2, 5 2, 4 2, 3, 6			$N_R =$	125			3.250	
		2.301075							-					3.172413 3.10	2, 4, (8)
13	95	2.273684	2, 3, 4, 6, 8	35	53	3.320754	2, 4, (8)	59	6	21.833333	4.			3.10	2, 3, 6
12	97	2.247422	2	34	55	3.236369	2	58	8	10.0250	(7) (3, 5)			3.032258 2.968750	
				33	57	3.157894	2. 3. 4. 5. 6	57	10	10.00					
		3.7	100	22	59	3.084745	2 2, 3, 4, 5, 6 2, 7	56	13	0.010384	2, 3, (6)	30	66	2.909090 2.852941 2.80	2, 3, 4, 6, 8
		$N_R =$	122				0 1 0	400	1.0	0.000000	2, (4, 5, 7)	29	68	2.852941	2
57	7	18.428571	3				2, 3, 6					-			
		14.555555						53	19	7.578947	2, 3, (4, 6, 8)			2.750	2, 3, 6
55	11	12.090909	(7)	29	65	2.892307	2, 4	52	21	6.952380	2				2, 4, 5, 8
55	12	11.166666						51	23	6.434782	2, (4)	25	76	2.657894	2
54	14	9.714285	2 (4 8)				2, 3, 4, 6, 8				2, 0, (0, 0)	24	78	2.615384	2, 3, 4, 6
E0.	10	0.0050	0 0 (0)	26	71	2.732394	2 4 7	49	27	5.629629	2, 4, (8)			2.5750	
03	16	7 777777	2, 3, (6) 2, (4, 5, 7)	20	13	2.084931	2, 4, 7	48	29	5.310344	2, (7)	22	82	2.536585	
			2, (4, 5, 7)	24	75	2.640	2, 3, 6	47	31	5.032258	2, 3, 4, (6)	21	84	2.50	2, 3, 5, 6, 7
			2, 3, (4, 6, 8)	23	77	2.597402	2, 3, 6 2, 4, 5, 8	46	33	4.787878	2			2.465116	2. 4
			2, 3, (4, 6, 8)	22	79	2.556962	2	45	35	4.571428	2, 4, (5, 8)			2.431818	
				21	81	2.518518	2, 3, 4, 6	44	37	4.378378	2, 3, (6)	18	90	2.40	2, 3, 4, 6, 8
48	26	5.692307	2, 4									17	92	2.369565	2
477	00	E 957149	0 9 (5 6)												
46	30	5.066666	2, 4, (8)	19	85	2.447058	2, 4, 8	41	43	3.906976	2, 3, 4, (6, 7, 8)				
45	32	4.81250	2, (7)	18	87	2.413793	2, 3, 5, 6, 7	40	45	3.777777	2 2, 3, 4, (6, 7, 8) 2, 5	15	96	2.31250	2, 3, 6
44	34	4.588235	2, 3, 4, (6)	17	39	2.382022	2, 4	-		0 00000	0.4	14	98	2.285714	2, 4, 7, 8
**		4 388888	2	16	91	2.351648	2 2, 3, 4, 6, 8								
43			2, 4, 5, (8)		-	0.00					0 0 0			0.00000	0 0 . 0

OZALID NEWSLETTER

NEW IDEAS TO HELP YOU WITH ENGINEERING REPRODUCTION AND DRAFTING



Standard materials, plus new thinking, result in big time and cost savings.

How to break the halftone costs barrier

Some of the sharper repro men looking to cut the high cost of using half-tones in quantity have come up with this little timesaver that goes for pennies per halftone. Here was the problem: 200 rush copies of 16 technical photographs were needed for a service manual...a total of 3200 prints. This job would usually run about \$2,000 and take ten days... that was too long and cost too much.

A bright lad thought about their Ozalid whiteprinting equipment and worked out this procedure: First an 8" x 10" screened film positive was made by projection from a 4" x 5" negative, emulsion away from emulsion.

This insured proper orientation of the print in the final stage.

Next, the film positive and Ozalid black-line plastic-coated paper (105SZ) were processed in an Ozalid Printmaster 810 at a rate of 12 feet per minute. The 42-inch width of this machine permitted two operators to work simultaneously, cutting total production time virtually in half! The choice of Ozalid paper Type 105SZ was an excellent one. It gave crisp; black-line images of great density due to the paper's plastic coating. The entire project took just under a fast six hours instead of the usual ten days, and cost about \$100.

Total savings: \$1900 and $9\frac{1}{2}$ days of production time. Pretty smart, we think. By the way, we've got sample packages available for the asking that might very well give you the same dramatic results. Why not write us at Ozalid, Box S4, Johnson City, New York. We'll be glad to help.

Looking for a fast case of the blues?

The happy kind, we mean. The clean, rich, decisive blue image that Ozalid's new Super-Speed Blue-Line (200SS) gives. And when we say fast, that's exactly what we mean. Poor originals are copied up to ten feet per minute faster than with regular copy papers.

This is the first Ozalid copy paper specifically designed for copying semi-opaque originals at higher speeds...at no sacrifice of line density in any sense!

But what does all this mean in practical benefits, other than increased production at no loss in quality?

Well, for one thing, it means that you can now do a fine job on semiopaque material, such as one-sided letters, documents and bulletins, at the lowest cost of any copying process...even if they're printed on bond papers!

Another benefit is the clean, readable copies you can now produce from soiled, yellowed documents and low-translucency materials much faster than ever before.

Is that all? Not by a long shot. 200SS actually turns low-powered ultraviolet machines into pretty fast units. And the faster printing speeds mean faster return of the original after each cycle.

Why not try this superb, highdensity blue-line paper today? It really makes sense. Just call your local Ozalid representative for a demonstration.

Ozalid - Division of General Aniline & Film Corp. In Canada: Hughes-Owens Co., Ltd., Montreal

Matching

Electrical Adjustable-Speed Drives

to load characteristics

UNDOUBTEDLY, the most important aspect of drive selection is performance. And the key to performance is proper matching of drive characteristics to load requirements.

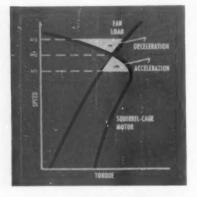


Fig. 1—Stable equilibrium of a squirzelcage motor and fan load.

The basic matching problem hinges on one factor—equilibrium. Load-torque requirements must be balanced by drive-torque availability under all operating conditions or equilibrium is upset. Upset can result in a stalled machine, destructive conditions, or acceleration to equilibrium at some other speed.

Typical torque relationships are demonstrated by the example of Fig. 1, a squirrel-cage motor driving a fan. The intersection of motor and fan curves represents a stable operating point.

This equilibrium point is termed stable since any momentary disturbances produce corrective forces tending to restore equilibrium. The stability of an equilibrium point rests with the type of intersection C. G. HELMICK

Industrial Engineering Dept. Westinghouse Electric Corp. East Pittsburgh, Pa.

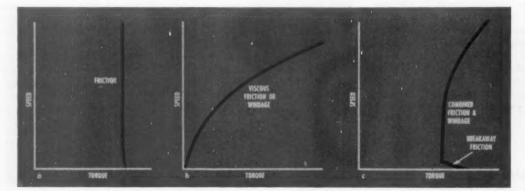
that the load curve makes with the drive curve. The relative slope of the two curves at this intersection is the determining factor. The condition for this kind of stability is

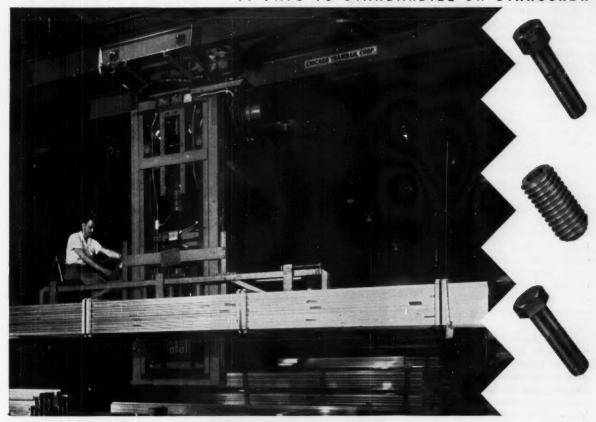
$$\frac{dT_{load}}{d\omega} - \frac{dT_{motor}}{d\omega} > 0$$

where T = torque and $\omega = \text{speed}$.

Load Characteristics: Loads can be broadly classified as passive or active. Passive loads absorb energy and demand torque only in opposition to motion. Active loads can

Fig. 2—Speed-torque curves of typical passive loads: a, Friction; b, viscous friction or windage; c, combined friction and windage.





17 different Stanscrew fasteners used in Chicago Tramrail's Trak-Rak

"In constructing our complete line of cranes we make no compromise with the most rigid requirements of safety," says S. W. Fountain, Vice-President, Chicago Tramrail Corporation. "Therefore, reliability is our principle reason for standardizing on quality components such as Stanscrew fasteners."

"But Stanscrew gives us more than fast service and reliable products. Their broad line of over 5,000 fasteners offers a wide selection . . . and their fastener specialists and engineers are always ready to assist our design department in determining the strongest, safest, most econom-

ical fastener for every application. For example, in our Trak-Rak stacking crane above, 17 different Stanscrew fasteners are used . . . each selected after careful study for the precise job it has to fill."

Like Chicago Tramrail, many other industrial leaders have learned it pays to capitalize on Stanscrew's backlog of over 80 years of fastener experience. To use this accumulated knowledge in solving your particular fastener problem, just call your Stanscrew distributor. He will quickly arrange for a visit from your Stanscrew fastener specialist.



CHICAGO ! THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

transmit energy, demanding torque whether or not there is motion. In the latter category are tension loads, gravity loads, and wind loads. Included also are certain combinations whose load demands change with time.

CONSTANT TORQUE: This the most common passive-load requirement because it is the characteristic of friction loading. Friction force is essentially constant regardless of speed. Therefore, the torque demand of such a load is also constant, Fig. 2a. Where equipment consists of rolls, belts, or cylinders turning in bearings, and where little energy is transferred to the work material itself, the load demand is typically constant-torque. Certain types of bearings may require extra torque at starting to "breakaway friction," overcome Fig. 2c.

Variable Torque: This classification is given to passive loads that are characterized by viscous or fluid-friction effects, Fig. 2b. Fans, blowers, and compressors fall into this class because their hydraulic loading is usually viscous friction. The "windage" effect associated with motors, or other parts rotating at high speed, is primarily viscous friction, and it also displays the "variable-torque" demand. This windage load often appears in combination with constant-torque loads at higher speeds, Fig. 2c.

An important exception concerns pumps. Not all pumps operate against fluid-friction loads. A boiler feed pump, for example, usually operates against a constant pressure in pumping feedwater into a steam boiler. This result is essentially a constant-torque demand.

TENSION: An often encountered active load is that of holding tension. Tension loads can appear in several forms: Pulling or holding back, either against constantspeed delivery rolls, or against tension-setting "dancer" mechanisms. In these latter devices, often used in the textile and rubber industries, the fabric is looped through a movable roll that is weighted to establish the sheet tension. Multiple loops and rolls may be ganged together to provide storage of fabric under tension during momentary differences in input and output

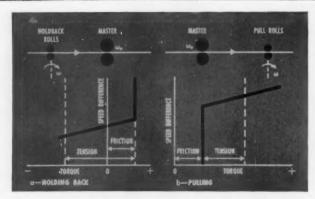


Fig. 3 — Speed-torque curves of active tension load for, a, holding back and, b, pulling.

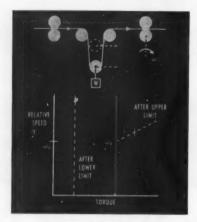


Fig. 4—Characteristic curve of pulling tension against dancer mechanism.

speeds of the fabric.

Holding tension against delivery rolls is shown in Fig. 3, and dancer tension is shown in Fig. 4. In both, the load demands torque whether or not there is motion, and energy is transmitted by means of the load.

Consider further the curves of Fig. 3, where tension is held against constant-speed delivery rolls. Ordinarily there is a friction component to this load due to roll bearings, and this is the only load until the roll surface speed matches the delivery speed. Any further speed difference establishes tension: Increase in surface speed for pulling, decrease for holding back. This accounts for the near-horizontal slope of the load curve.

The dancer mechanism, Fig. 4, establishes tension in the material regardless of roll speed. Within limits, the constant dancer tension produces a constant-torque demand. Different delivery speeds result in a different operating point on the

same curve. The dotted lines in Fig. 4 indicate existing limits of travel, after which the dancer plays no part in load determination.

TIME - CHANGING LOADS: Included in this category are loads that vary with time; for example, the core-type winder. This load is time-changing because roll radius increases with time. For any given roll radius the load demand is the familiar tension characteristic curve. As the radius grows, however, both load torque (product of tension and radius) and drive speed (surface speed divided by roll circumference) change correspondingly.

Drive Characteristics: Drives for adjustable-speed operation can be described by two curves. The first can be termed the characteristic curve, which is the familar speed-torque curve, or family of curves. This curve describes the ability of the drive to meet load demands.

The second curve can be called the capability curve, which describes the maximum continuous load that the drive is capable of carrying at any speed in its operating range. The capability curve is usually a thermal limitation of the drive. The reason for this twofold classification is that the drive motor will develop only as much torque as the load demands, regardless of its capability to deliver more. Thus, load variations will occur along the characteristic curve even beyond the capability limit, if the load demand is not sustained continuous-

Characteristic and capability curves of common adjustable-speed

The TUTHILL Internal Gear Pump...and its advantages in reversing applications

by E. H. Schanzlin, Chief Engr., Tuthill Pump Co.

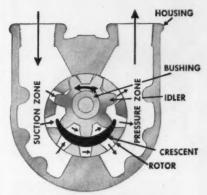
Extremely high reliability, proven in thousands of applications over a 30 year period, has made Tuthill's Internal gear pump an industry standard. The Internal gear construction particularly adapts itself to reversing pump applications as indicated in the sketches at right.

How It Operates

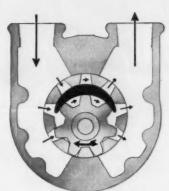
Key elements are the rotor, idler gear and the crescent shaped partition. This crescent shaped partition, shown in heavy black, is cast integral with a moving part called the idler carrier.

In the drawing at left, power is applied in counterclockwise rotation to the rotor and transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the rotor is sealed by the crescent. When the pump is started, there is an increase in volume as the teeth come out of mesh. This creates a partial vacuum, drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and rotor and is carried past the crescent to the pressure side of the pump. When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port.

When shaft rotation is changed from counterclockwise to clockwise, as in the drawing at right above, the idler carrier, (including the idler gear and crescent) automatically rotates 180° through the suction zone. This changes the directional flow within the pump without changing port positions. The idler carrier rotates in a cover casting fitted with stops so that



COUNTERCLOCKWISE ROTATION



CLOCKWISE ROTATION

the crescent can rotate only 180°—always through the suction zone. If rotation were again reversed to counterclockwise, the crescent would swing back to its original position (shown at left above).

No valves required . . . ports remain constant

This unique construction permits positive reversing action, without any valves, and with the port positions remaining constant. In addition Tuthill's reversing pumps provide all the other attributes of internal gear construction . . . extremely high reliability, compactness, and high efficiency.

Reversing Pumps with internal gear construction pay particular dividends on applications where the pump must be driven from a reversing shaft or when machinery must be shipped without knowing the ultimate direction of the driving unit.

375 reversing pump models

Tuthill offers a complete selection of over 800 different pumps including 375 different reversing pump models for capacities from ½ to 200 GPM; for pressures to 400 PSI; and speeds to 1800 RPM. These include a complete selection of stripped models for incorporation into products. Specially designed housings, shaft extensions, relief valves and many other features can be developed by Tuthill's engineers to meet the requirements of specific applications.

Catalog 105 contains complete information on all Tuthill Reversing Pumps. Write today for your copy.



Typical Tuthill Reversing Pump. Model 2RC has capacity of 5 GPM operating at 100 PSI, 1200 RPM.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressure to 300 PSI; speeds to 3600 RPM.





Are Small Precision Metal Parts Getting In Your Hair?

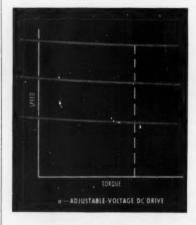
If you need precision in small metal parts you can get it from Torrington – plus exactly the right finish, temper and hardness required for your needs. Moreover, Torrington can produce such parts at high speed and a remarkably economical cost. We are the leading specialist in this field—with the specialized skills, engineering experience and facilities to save you money. If you have small parts to be manufactured in large quantities why not let Torrington solve your entire problem. Use the coupon below to get prompt action.

progress through precision SPECIAL METAL PARTS

THE	TORRINGT	ON C	OMPANY	Torrington, Conn
	Г			
	The Torringto		, Specialties Division, Conn.	on
	Please send	me literatu	re on Torrington Sr	nall Parts.
(030)	Piease have	your repre	sentative contact u	6.
(0.5)	Name	your repre		Title
	4	4		
	Name	4		

drives are shown in Fig. 5.

The dc drive with armature-voltage control, Fig. 5a, has a constantspeed characteristic curve, and a



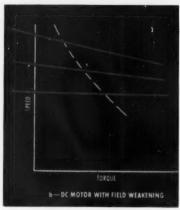


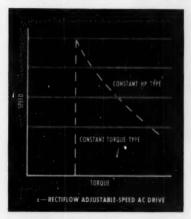
Fig. 5—Inherent speed-torque characteristics of typical adjustable-speed drives: a, adjustable-voltage dc drive; b, dc motor with field weakening.

constant-torque capability curve. Constant torque arises from constant flux and maximum current (torque = flux × current).

The dc drive with field-weakening control, Fig. 5b, has a constant-speed characteristic curve with a constant - horsepower capability curve. Constant horsepower is implied by constant line voltage and constant maximum current.

The Rectiflow adjustable-speed ac drive, Fig. 5c, has constant-speed characteristic curves. It is built to have a capability curve that is either constant-torque or constant-horse-power.

The constant-torque nature of the eddy-current coupling drive is shown by the characteristic curves



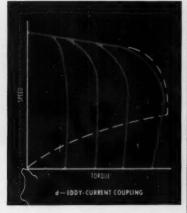
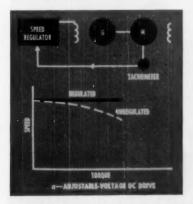


Fig. 5—Inherent speed-torque characteristics of typical adjustable-speed drives: ϵ , adjustable-speed ac drive; d, eddy-current coupling.



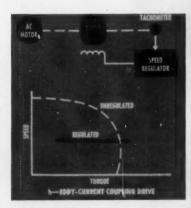


Fig. 6—Modification of inherent drive characteristics by speed regulator on, a, adjustable-voltage dc drive and, b, eddy-current coupling drive.

in Fig. 5d. The upper capability curve is set by the maximum excitation, and the lower curve is determined by the machine's ability to dissipate the high heat losses at low speeds.

Modification of Drive Characteristics: Since adjustable-speed drives furnish a limited number of inherent characteristics, it is sometimes desirable to modify these characteristics to match a particular load requirement. Regulators can be used for this purpose. Furthermore, a regulator can supply precision that often is not inherent in the characteristics of an unregulated drive.

Speed Regulators: A tachometer can be used to measure actual drive speed and, when combined with proper regulating elements, can correct drive speed to keep it precisely constant, Fig. 6.

CURRENT REGULATOR: This type

of regulator, when used with an adjustable-voltage dc drive produces a major change in the speed-torque curve, Fig. 7. The new characteristic curves are constant-torque, since motor torque is proportional to current for a fixed value of ex-

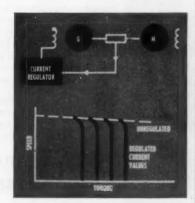


Fig. 7—Modification of dc drive characteristics by current regulator.

Circle 495 on Page 19

LOAD VARIATIONS

Low Friction of a hall.

Under normal loads, 60% roller contact.

Under contact.

Here's why Shafer Bearings add plus stamina and easy go to heavy-duty equipment. Rollers are concave; races are convex. Under normal loads, only 60% of a roller contacts the race—reducing friction to that of a ball. Under shock loads, the tough bearings automatically compress—increasing the bearing area to fit the load requirement.

Shafer Bearings retain load capacity under toughest radial and thrust loads and misalignment. Mail the coupon.



CHAIN Belt Company 4643 W. Greenfield Ave., Milwaukee 1, Wisc (In Canada: CHAIN Belt (Canada) Ltd., 1181 Sheppard Ave. East, Toronto)	onsin
() Please send Shafer Bearing Catalog 59.	A.
1000	

()	Please	sene	1 S	ha	fe	Be	ea	ri	Ø	ıg	(à	ıtı	ıl	0	g	9	15	1/	١.						
Nami	e																									
Comp	any									.,									0,6							
Add	ress																									
City.	*****								2	o	ue					. 3	S.C.	a	te				*			



178

a Baher Industrial Trucks, dir. of Otis Elevator Co., Clave

Circle 496 on Page 19

Machine Design

citation.

The same current regulator, when used as shown in Fig. 8, also forces

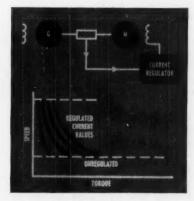


Fig. 8-Modification of dc drive by current regulator in motor field.

a complete change. The new characteristic curve is constant-horse-power, resulting from a fixed voltage and constant current.

Dancer Regulator: The use of the dancer mechanism to establish fabric tension was discussed under tension characteristics. The

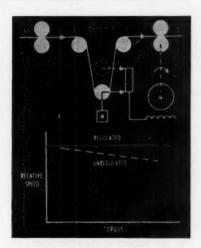


Fig. 9—Modification of inherent drive characteristics by dancer-roll regulator.

dancer can be further utilized to provide a control signal for regulating the relative speed of one motor with respect to another, Fig. 9. The position of the dancer mechanism is directly proportional to the relative angular difference between the pullrolls and holdback rolls. Thus, if the position of the dancer is maintained constant by means of a dancer regulator, the controlled

drive will be synchronized with the other drive.

Design Approach: The method of attacking drive-load matching problems has certain well-defined steps.

First, load requirements must be examined to determine load characteristic curves. Second, available drive characteristics are checked for possible solutions. Load and drive curves are matched to determine performance suitability. If more than one suitable solution is possible, the problem becomes one of economic choice. Such factors as initial cost, installation cost, operating and maintenance expenses, and flexibility for future use must be considered. One choice will then generally show overall superiority. Such a procedure should insure a sound application.

"Matching Load and Drive Characteristics," Westinghouse Engineer, Vol. 20, No. 2, March, 1960, pp. 46 to 50.

electrical

Fast-Response Control for Reversible-Adjustable AC Drive

C. B. Sandborn, Square D Co.

An improved ac static-control system which does not require an auxiliary electric load brake to obtain good speed regulation. Economy and availability of ac power have led to steady growth in the application of ac motors. Because static-control devices assure high reliability and long life expectancy, they are being included in new systems to eliminate nearly all electromechanical devices. Saturable reactors, magnetic amplifiers, and silicon-controlled rectifiers are some of these static devices.

The new system described in this paper includes such refinements as: 1. Infinite speed control to eliminate stepped speed points. 2. Application of a safety power-limit switch to a static - control system. 3. Unitized control-panel components to provide convenient circuit test points for maintenance purposes. This new system is being applied to a standard wound-rotor induction motor, and offers possibilities for use with squirrel-cage induction



Want continuous production...to cut installation costs? Investigate the advantages of Rex Segmental Rim Sprockets and Traction Wheels. Tough, long-lasting special cast steel rims bolt simply to either split or solid hub body. When, after long service life, replacement is required, all you do is replace the worn rim...the hub body remains on the shaft. Mail the coupon.



SPROCKETS AND WHEELS

4643 W.	Belt Company Greenfield Ave. see 1, Wisconsin	110-A
(In Cana	da: CHAIN Belt (Car eppard Ave. East, Tor	nada) Ltd., ronto)
Send :	ne my copy of Bulleti a Rex man call.	in 55-55.
Name		
Company.		
Address.		********
City	Zone	State



motors. The only requirement for the squirrel-cage motor is that it have the proper inherent speedtorque characteristics.

AIEE Paper No. DP 60-646, presented at the AIEE Great Lakes District Meeting, Milwaukee, April, 1960, 8 pp.

Analysis of the Dynamics of An Electromechanical System

Roy Hyink, Cutler-Hammer, Inc.

A method for accurate computation of the dynamic operating characteristics of an electromechanical system. This method is based upon the principle of conservation of energy and is particularly useful in systems where energy is transformed from one form to one or more other forms. Total energy input to the system must equal the energy output plus the losses within the system plus the energy stored in the system. With this approach, digital computers can be used to do the calculations in a reasonable length of time.

AIEE Transactions Paper No. 60-636, presented at the AIEE Great Lakes District Meeting, Milwaukee, April, 1960, 11 pp.

processes

Explosive Forming

Floyd A. Cox, manufacturing preplanning manager, and Ernest F. Mellinger, technical advisor, Ryan Aeronautical Co.

Four aspects of explosive forming techniques: Advantages of highenergy forming, selection considerations for parts to be explosiveformed, present state of the art, and future areas of development.

Prime advantages of using explosive forming are: Its economics, its ability to hold close tolerances in the formed components, and its ability to minimize the number of pieces required for an end item. It affords a means of fabricating parts out of superalloys which are extremely difficult to form by other means, and it offers a new forming method for intricate parts which were previously impossible to form by conventional means.

Types of parts best suited for explosive forming are: Cylindrical parts for the entire form operation, relatively flat parts that are formed by conventional means and resized

to closer tolerances, superalloy parts and components that do not lend themselves to conventional forming methods.

Emphasis in the future will be directed toward further refining the operation to make it more productive. In addition, techniques are being developed to explosive-form superalloys and refractory materials while they are heated. Currently, research is being conducted on a technique whereby media other than water are used for transmitting the explosive energy to the material to be formed. In this way, blanks can be resistance or induction heated and subsequently formed.

Explosive forming has applications in compacting metal and ceramic powders; forging; blanking and piercing; embossing; and pressure welding.

SAE Paper No. T39, presented at the SAE National Aeronautic Meeting, New York, April, 1960, 3 pp.

Precise Duplication By Hydraulic Tracing

Herman Horlacher and Benjamin W. Carter, Cincinnati Milling Machine Co.

Employment of the hydraulic servo principle as a guidance system for contour milling. The basic hydraulic principle is analogous to the electrical Wheatstone bridge and substitutes hydraulic for electrical resistances.

The quantity of oil flow to the machine actuator is a function of the pressure drop and the porting area. The pressure drop and porting area are obtained by the plunger moving off its null position. Calibrated tracer valves register 20-psi pressure differential when deviating from null less than 0.000025 in. The farther the valve plunger is displaced from null, the greater the flow of oil. A light-weight duplicator slide, designed and built with care and rigidity, can follow a small tracer signal accurately at high velocity without oscillation. are designs where several axes are controlled by individual tracers and each operates off its own contour template.

ASLE Paper No. 60AM 1C-3, presented at the 15th ASLE Annual Meeting, Cincinnati, April, 1960, 15 pp.

techniques

Engineering Application of Digital Computers

H. D. Irwin, mechanical equipment consultant, Engineering Service Div., E. I. du Pont de Nemours & Co.

Are computers worthwhile, and are they being used effectively? This question is discussed from the viewpoint of the practicing engineer.

Efficient use of machine computation in engineering work requires two things: 1. Acceptance by engineers and supervisors of an engineering philosophy which can profitably use computation. 2. Reduction of the high cost of computer Obtaining accepprogramming. tance for machine computation is essentially an educational problem which must be undertaken by engineering societies and industry itself. The high cost of programming can be alleviated, at least in the short term, by the adoption of universal computer languages in conjunction with program libraries.

ASTME Paper No. 278, Vol. 60, Book 1, presented at the 29th Annual Meeting of ASTME, Detroit, April, 1960, 4 pp.

Identification of Machine Tool Lubricants

M. W. Papp, Warner & Swasey Co.

A progress report from the Machine Tool Industry Council of the ASLE.

ASLE Paper No. 60AM 6B-2, presented at the 15th ASLE Annual Meeting, Cincinnati, April, 1960, 9 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 50 cents to members, one dollar to nonmembers.

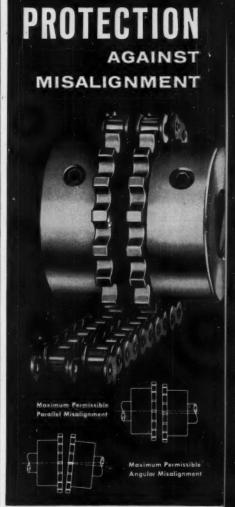
ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill.; papers 50 cents to members, 75 cents to nonmembers.

ASTME—American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave., Detroit 38, Mich.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

Westinghouse Engineer, P. O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa.; individual copies 50 cents.

Circle 499 on Page 19->



For positive protection against unavoidable misalignments...for positive power transmission...for high strength and long life...at low cost, use allsteel Rex Roller Chain Flexible Couplings. They compensate for both angular and parallel misalignment... absorb shocks and vibration...provide maximum flexibility with minimum backlash. For complete, cost-saving facts...compare! Mail the coupon.



FLEXIBLE COUPLINGS

CHAIN Belt Company 4643 W. Greenfield Ave. Milwaukee 1, Wis.	413
(In Canada: CHAIN Belt Canad 1181 Sheppard Ave. East, Toronto	a Ltd., Ontario.
☐ Send me my copy of Bulletin	577.
Name	
Company	
Address	
CityZoneS	tate

Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Bonded Lubricating Films

Dry lubricating films, bonded to rubbing surfaces, are described in new bulletin. Films greatly reduce friction, provide positive lubrication beyond intended life of equipment, and prevent corrosion, wear, galling, and seizure. Bulletin describes three types of film, and provides graphic information on speed, load, time, temperature, metal hardness, film hardness, procedure, pretreatment, and application. 8 pages. Bemol Inc., 131 State St., Boston 9, Mass.

- Circle 621 on Page 19

Custom-Built Elastomers

Bulletin 902 titled, "Achieving Better Designs with Custom-Built Elastomers," features illustrated examples of custombuilt elastomers that helped turn ideas into useful products. Two-page chart lists the general properties of the ten major elastomers. It describes the origin and composition of natural rubber and nine synthetic elastomers, and lists their physical and chemical properties, processing properties, and environmental resistance characteristics. 6 pages. Lord Mfg. Co., Erie, Pa.

Circle 622 on Page 19

Centrifugal Pump

Small, low cost, canned centrifugalpump that cannot leak is described in Bulletin 670-E. Large cutaway drawing of the unit is provided, and many advantages are listed. Specifications are included, including capacity chart. 4 pages. Fostoria Corp., Dynapump Div., P. O. Box 35-6, Huntingdon Valley, Pa.

Circle 623 on Page 19

Power Supplies

New power-supply handbook and catalog gives tabular specification data on more than 400 separate power-supply models. Publication covers regulated dc supplies, frequency changers, high-voltage power supplies and other high-voltage products, miniature transistorized power supplies, inverters and converters, and ac line-voltage regulators. Technical data on the selection and application of the products are included. 32 pages. Sorenson & Co. Inc., Richards Avenue, South Norwalk, Conn.

Circle 624 on Page 19

Industrial Plastics

Bulletin BR-l contains property and application data on mill shapes of nylons, TFE fluorocarbons, polycarbonates, chlorinated polyethers, and cross-linked polystyrene available from 50 stock locations. Information on Fluorosint TFE-base resin is included, as well as data on nylon pressure hose and tubing. 12 pages. Polymer Corp. of Pennsylvania, 2140 Fairmont Ave., Reading, Pa.

Circle 625 on Page 19

Miniature Lamps

Pocket-sized booklet lists all known standard miniature lamps available and the sources of supply. Specifications for about 400 lamps are given, as well as complete lamp nomenclature with drawings of lamp styles and descriptions of parts. 24 pages. Chicago Miniature Lamp Works, 1500 N. Ogden Ave., Chicago 12, Ill.

Circle 626 on Page 19

Bearing Bronzes

New illustrated booklet describes the various Promet bronze formulations. Listed are data on applications, composition, physical properties, and availability of bar stock. Charts of brass and bronze casting alloys, of manganese-bronze alloys, and of aluminum-bronze alloys are presented. 16 pages. American Crucible Products Co., Lorain, Ohio.

Circle 627 on Page 19

Electrical Motors

Colorfully illustrated Bulletin GED-4066 discusses features and lists advantages of full line of integral Tri/Clad "55" motors. Bulletin provides information on performance and design, as well as on electrical, mechanical, and physical protection. Pictorial listing of the full line is included. 16 pages. General Electric Co., Schenectady 5, N. Y.

Circle 628 on Page 19

Thermistor Elements

Various types of thermistors for hightemperature and commercial application are described in new bulletin. Typical curves are presented for resistance vs temperature, voltage vs current, and timedelay characteristics of the several types. 6 pages. Walter Kidde & Co. Inc., Electronics Dept., Aero-Space Div., 9 Brighton Rd., Clifton, N. J.

Circle 629 on Page 19

Plastic Products

Form 9703 features plastic products of Teflon, Raylon, and Kel-F. Included are mechanical and electrical properties of the products, with graphs. Booklet illustrates and describes in detail basic shapes available, as well as mechanical packings

and gaskets; accessories for fluid-handling equipment; custom-machined parts; thinwall tubing; flexible wire-braided, aircraft, industrial, and rubber-covered hose; bondable Teflon and adhesives for bonding; O-rings and back-up rings; bearings; and Teflon coatings. 36 pages. Raybestos-Manhattan Inc., Plastic Products Div., Manheim, Pa.

Circle 630 on Page 19

Valve Line

Revised Condensed Catalog 10-A provides descriptions of line of bronze, iron, and forged-steel gate valves; bronze and iron globe, angle, and check valves; asbestos-packed iron cocks; bar-stock valves; valve parts; steel and forged valve accessories; and cast-steel valves. Operating specifications, characteristics, sizes, ratings, and illustrations are presented in easy-to-read tabular form. 16 pages. American Chain & Cable Co. Inc., R-P & C Valve Div., Reading, Pa.

Circle 631 on Page 19

Hardness Testing Data

New data card chart shows the approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels. Hardness systems covered are Brinell, Monorron, Vickers, Rockwell (B, C, and E scales), and Scleroscope. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.

Circle 632 on Page 19

Teflon Tube Fittings

Ten types of Vari-Grip Teflon tube fittings are described in Bulletin 772. Fittings eliminate the need for glass-ball joints and other glass fittings and connectors. Specifications and prices for complete line of fittings are included. 4 pages Beckman Instruments Inc., Scientific & Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

Circle 633 on Page 19

Resistors and Coil Forms

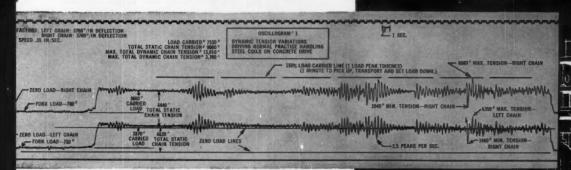
Products covered by catalog on resistor and coil forms include ½, 1, and 2-w fixed-composition resistors that meet or exceed all requirements specified by MIL-R-11 and RS 172. Descriptive data include dimensions, derating curve, color code, and table of standard resistance values and tolerances. Other sections deal with phenolic coil forms and special resistors in nonstandard shapes and material combinations. 4 pages. Speer Carbon Co., Resistor Div., Bradford, Pa.

Circle 634 on Page 19

Pace-Setting Research and Development...

Field Dynamic Load Testing Predicts Chain Life

the BIG



Oscillogram ... during transportation of load

In the selection and application of chains, machine designers have recognized that fatigue life rather than ultimate strength ratings is the key to correct chain selection. Repeated cyclic stressing causes chain failures even though operating loads are well below the rated ultimate strength of the chain.

CHAIN Belt engineers are continually developing test data to establish endurance limits and fatigue life ratings for chains and chain parts. These data were used in the design and material selection of Rex Chains. But laboratory conditions cannot always accurately determine the variations in cyclic stressing that occur in many actual applications.

To provide the accurate data required for precise chain selection, CHAIN Belt engineers developed equipment for determining dynamic loading for chains operating in actual service. From this library of field test and laboratory data, actual predictions of chain fatigue life are made and chains are designed to provide maximum resistance to cyclic stressing. Here's just one example:

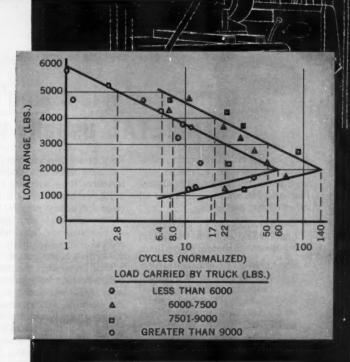
On a lift truck, subject to abnormal service conditions, chains were giving only three to four months' life. By using strain gauges on the chains during operation and recording actual load patterns on an oscillograph, it was clearly shown that most of the fatigue damage occurred while the lift truck was transporting the load, rather than when picking it up. Cyclic loadings rather than static tensile loadings were causing the failures.

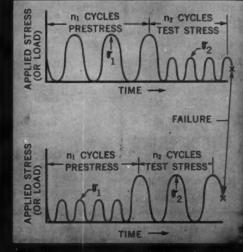
From these data, a chain was designed that has not failed in three years, compared to the previous three months' service.

To assure longest service life for the chains, sprockets, roller bearings, and flexible couplings you specify, we suggest you have a CHAIN Belt sales engineer review your requirements. Write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis.



Circle 500 on Page 19







Miniature Gages

Bulletin 59-1 describes miniature vertical-type gages with 5-in, scales for measuring and indicating draft, pressure, differential pressure, temperature, and pneumatic signals. Bulletin shows such features as scales and ranges available, mounting dimensions, and lighting details. 12 pages. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, III.

and exect me. they are trustles being t

Circle 635 on Page 19

Drafting Aids

Quick-reference Bulletin P-30 provides a table which covers all precut shapes and sizes of pressure-sensitive drafting aids required to make printed-circuit drawings that conform to military and new nonmilitary configurations. Ilustrations are provided in chart form for easy cross reference between corresponding donut, teardrop, and twin-pad sizes. Purposes of the several kinds of tape used are fully explained. 6 pages. By-Buk Co., 4314 W. Pico Blvd., Los Angeles 19, Calif.

Circle 636 on Page 19

Hollow Aluminum Bar Stock

Revised illustrated brochure lists extended range of sizes for hollow aluminum bar stock, now available in all alloys in ODs to 4 in. and wall thicknesses to ½ in. Publication provides complete tables for standard sizes in round and hexagonal rod and bar, giving wall thicknesses, dimensions, and weight per foot. Tolerances, mechanical properties, and specifications for hollow machining material are also presented. 8 pages. Harvey Aluminum Co., 19200 S. Western Ave., Torrance, Calif.

Circle 637 on Page 19

Hydraulic Cylinders

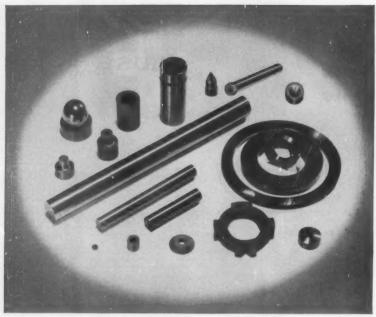
Bulletin Supplement S-113-1A covers benefits derived from the use of straight-thread cylinder ports. Supplement also contains a table for determining proper straight-thread port sizes for 1½ through 8-in. bore cylinders, and explains the advantages of using straight-thread ports in hydraulic cylinders. 2 pages. Hannifin Co., Dept. 116, 501 S. Wolf Rd., Des Plaines, Ill.

Circle 638 on Page 19

Shaft Position Encoders

Brochure titled "Shaft Position Digital Encoders With Magnetic Readout" gives complete specifications for 13-bit, 8-bit, and incremental encoders. Operating principle of the new type of magnetic readout is described in detail with illustrations. Recommended simplified transistor circuitry is given for interrogation, playback, detection, and amplification of the encoders. Conversion table is included for conversion from binary code to decimal or Gray codes. 12 pages. Electro-Mechanical Research Inc., Ascop Div. P. O. Box 44, Princeton, N. J.

Circle 639 on Page 19



Kennametal can be supplied as standard rectangular blanks, discs, rods, tubes, flats, balls, rings . . . and can be extruded, pressed, machined or ground . . . to precise tolerances for specific requirements.

When other materials won't do ... KENNAMETAL* usually will

High hardness and strength; resistance to abrasion, corrosion and high temperatures set Kennametal hard carbide alloys apart from all other design materials.

- Kennametal has an extremely high YME...up to 94 million psi compared to steel's 30 million.
- Some grades of Kennametal have a density as high as 15.5 gms/cc
 . . . twice that of heat treated steel . . . while other grades stand up for days in boiling 5% HNO₃ and 5% H₂SO₄.
- Kennametal is extremely hard... up to 94.7 Rockwell A.
- Kentanium,* a series of hard titanium carbide alloys, retains sufficient strength for many applications at temperatures as high as 2200°F.

See our display BOOTH 1305

DESIGN ENGINEERING SHOW

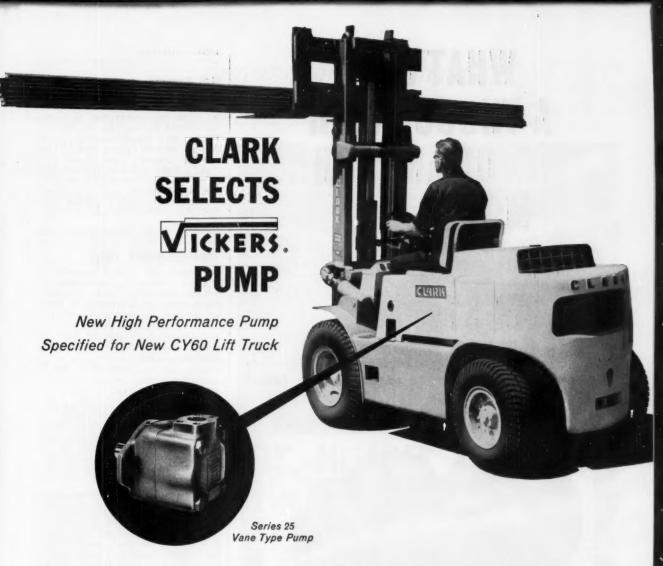
New York Coliseum May 23-26 Very broad applications have been found for these remarkable characteristics: long-wearing plungers, compressor cylinder liners, seal rings for rotary pumps, bushings, valve parts, high temperature sensor elements and hundreds of other critical component parts are being made from Kennametal.

Pushing design frontiers ahead means forcing back the barriers of wear, pressures and temperatures. For example, a pump manufacturer recently used Kennametal to obtain a large pumping capacity from a small pump. Using Kennametal for critical operating parts permitted faster speeds and higher pressures, without increasing pump size. A simple answer, but made possible only by the great wear- and corrosion-resistant characteristics of Kennametal.

Perhaps Kennametal can solve one of your problems. If you'd like more information, write for our Booklet B111A, Department MD, KENNAMETAL INC., Latrobe, Pa.

*Trademark

KENNAMETAL
...Partners in Progress



Faster, rugged, more maneuverable lift trucks in the 6,000 to 8,000 lb range added recently to the Clark Equipment Company line offer performance characteristics to match their modern streamlined appearance. Dependable hydraulic power and a newly designed power steering unit make these vehicles outstanding performers in the materials handling field.

In order to assure unmatched performance, Clark specifies a Vickers Series 25 vane-type pump and the new 2000 psi Vickers power steering unit as original equipment. These new Vickers high performance pumps are specifically designed for material handling and construction vehicles. They assure that you'll get more work from less input power due to the new exclusive vane construction.

Pump models now available deliver up to 75 gpm at pressures up to 2000 psi and 2000 rpm. Larger sizes and double pumps are due to be added to the line in the near future making it the most comprehensive line of high speed, high pressure pumps ever offered for mobile equipment.

Complete Pump Overhaul in Just 10 Minutes . . .

For all the data on the new High Performance pumps see

Bulletin M5108. New Bulletin M5110 gives complete

information on the new high pressure power steering systems.

Vickers "packaged" replacement cartridges containing all the normal wear parts often permit field changes without removing pump from vehicle, usually without disconnecting hydraulic lines. You get "as new" results with this simple changeover.

Write for your copies today.



VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

Mobile Hydraulics Division ADMINISTRATIVE and ENGINEERING CENTER Department 1430 . Detroit 32, Michigan

ilication Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND . DETROIT . HOUSTON . LOS ANGELES AREA (EL Segui MINNEAPOLIS . NEW YORK AREA (Springfield, N.J.) . PITTSBURGH AREA (MI. Lebenon) . PORTLAND, ORE. . ROCHESTER . SAN FRANCISCO AREA (Berkeley) . SEATTLE . ST. LOUIS . TULSA

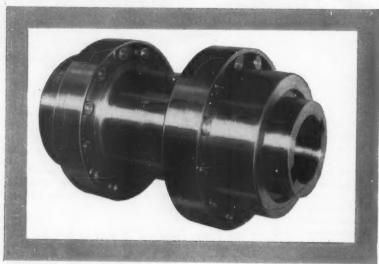
ALSO SOLD AND SERVICED IN AUSTRALIA, ENGLAND, GERMANY & JAPAN IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto, Montreal & Vencouver

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

WHAT'S A THOUSANDTH OF AN INCH... MORE

OR LESS?

With couplings operating at high peripheral speeds, it can mean the difference between early failure and long trouble-free life.



That's why all Waldron high speed coupling forgings (of SAE 4140) are "rough machined" to $\pm .001$ ", $\pm .000$ ", and then hand finished (sleeves first, then hubs). Bolts and nuts are weigh balanced, and the assembled coupling dynamically balanced as a unit—then match marked for reassembly.

Waldron high speed couplings are now operating at speeds of 70,000 rpm and more, and in drives up to 48,000 HP.

Even if your requirements don't involve such demanding service, it's good to know you have an extra margin of safety and reliability when you specify Waldron High Speed or any Waldron Coupling:

WALDRON



WALDRON-HARTIG DIVISION Midland-Ross Corporation

P. O. Box 791 · New Brunswick, New Jersey

HELPFUL LITERATURE

Ball Bearings

Type HDR high-precision radial ball bearings, with load capacities from 19 to 55 per cent greater than equivalent size Conrad bearings, are described in Catalog 60. Offered in ABEC-3 and ABEC-5 precision grades, bearings are made in Extremely Light, Extra Light, Light, and Medium series in metric sizes to 85 mm OD. Information on sizes, lubrication, materials, load ratings, and construction is furnished. 8 pages. MPB Inc., Split Ballbearing Div., Lebanon, N. H.

Circle 640 on Page 19

Aluminum-Bronze Alloys

Chemical and physical properties of a series of special aluminum-bronze alloys are contained in Bulletin 33e. Nine major grades and heat-treated variations are described. Closely controlled chemical limits are shown, and recommended applications for each grade are listed. 20 pages. Ampco Metal Inc., Box 2004, Milwaukee 1, Wis.

Circle 641 on Page 19

Aircraft Lock Nuts

High-strength FN 26 aircraft lock nuts, rated at 260,000 psi tensile strength, are described in Form 2608. Photos, charts, and line drawings point up design and performance features described in the text. Complete specifications are provided. Standard Pressed Steel Co., Box 102, Jenkintown, Pa.

Circle 642 on Page 19

Tantalum Capacitors

Bulletin 6.111-2 provides complete information on tantalum electrolytic capacitors for elevated-temperature applications. HP-type units designed for operation in ambient temperatures to 125 C are covered. Information includes detailed specifications, physical dimensions, ratings, curves, performance characteristics, and application data. 8 pages. Fansteel Metallurgical Corp., Dept. MD-1, North Chicago, Ill.

Circle 643 on Page 19

Resilient-Mounted Motors

Bulletin MU-245 lists motors, 1/6 through 10 hp, available with resilient mountings. Bulletin covers mounting construction, types of motors, and application recommendations. 4 pages. Wagner Electric Corp., 6400 Plymouth Ave., St. Louis 33, Mo.

Circle 644 on Page 19

Relay Specifications

Relay Folder R-200 provides data sheets for three basic types of relays: 5-amp series, 10-amp series, and specialty relays, including crystal can relay and line-mounted type. Folder contains 12 sheets of specifications and information. Request on company letterhead from Electronic Specialty Co., Relay Div., 5121 San Fernando Rd., Los Angeles 39, Calif.

Problem: How to Microfilm Old Drawings So They Can Be Read

Microfilming is widely used for recording and storing the mountains of draw-ings and data individual companies must maintain. But to anyone who works with microfilmed drawings, they know the condition of the original is very critical in order to obtain a readable microfilm print. Faint lines, weak lettering and dimension markings, creases, and dirt smudges become impossible handicaps when the originals are first reduced 16 to 29 times and then enlarged for reading or reproduction. Today's advanced drafting techniques avoid this problem in new drawings, but what about a com-pany's old drawings? Few are ever suitable for microfilming without extensive, meticulous restorative work. Yet, something must be done with these old drawings if the microfilm file is to be complete and useful.

Dietzgen answers this problem with a number of products and techniques developed for restoring old drawings



Dietzgen's "wash-off" process puts new life into old drawings quickly and inexpensively.

preparatory to microfilming. The Dietzgen "wash-off" process is preferred by many because no darkroom work is involved. Corrections are easily made on the "wash-off" media eliminating the tedious retouching of a photographic negative. Backgrounds come clean with a wipe of a brush or sponge so that even the finest line stands out sharp and clear

Today thousands out sharp and clear.
Today thousands of old drawings which appeared hopeless subjects for microfilming have been salvaged by



JETS, MISSILES AND DIAZOS

A large manufacturer of components for jet aircraft and guided missiles complained: "We're having trouble getting all the prints we need each day with our present printmaking facilities. We must step up our printing speed. However, we want to standardize on blueline diazo prints and would like to run our printers at very nearly a constant speed. Also, we have to work with a wide range of reproducibles, which really complicates the problem."

Four companies coating diazo papers were given the problem. Two immediately said it was impossible. The third

Dietzgen products and techniques . . . and it's this experience which can prove invaluable to you if old drawings have handcuffed your company's microfilm

program.

submitted a specially coated stock which provided the speed but not the print quality required.

Dietzgen had answered similar problems before. With a slight formula change in one of the regularly catalogued Dietzgen diazo papers, the extra speed was added to all the other needed characteristics already in formulation. This custom-engineered product was tested and immediately adopted. It has since been used continuously for the company's large volume needs and is pronounced "perfect." Print production soared.

Dietzgen's long and broad experience with Diazo coatings and equally long and broad research program frequently combine to provide both counsel and advanced products not obtainable elsewhere.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems



This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advanced techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the

efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-D-160, Eugene Dietzgen Co., Chicago 14, Illinois.

dies and a second

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Retaining Ring

self-locking unit is two-turn, spiral-wound type

Spirolox self-locking retaining ring incorporates two slots and two punched tangs to effect self-locking action. The two-turn, spiral-wound ring locks when centrifugal force is applied at high-speed rotation, or when dirt or other foreign material tends to force retaining ring out of its groove. Ring is flat spring steel, coiled on edge to make a 360-deg retaining surface. Ring can be coiled to any diameter within the



limits of the material used and can be furnished in a variety of materials and finishes. Inherently balanced, ring is especially suited for high-speed applications. Ramsey Corp., Box 513, St. Louis 66, Mo.

Circle 645 on Page 19

Electric Motor

uses flat printed-circuit type armature

Pancake-shaped electric motor for servo and instrument use employs a flat printed circuit instead of conventional wire-wound armature. Light weight of the rotating portion, about one-eighth the weight of conventional armatures, permits motor to reach full speed within a few thousandths of a second. Smooth torque at low speeds, coupled with extremely low armature inertia, allows printed motors to be used for



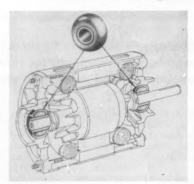
direct drive in servo applications without costly gear trains. Low armature inductance eliminates sparking normally associated with communitating. Two sizes are available. Model PMI-PM368 is $4\frac{1}{4}$ in. in diam and $2\frac{1}{4}$ in. long; Model PMI-PM488 is $5\frac{5}{8}$ in. in diam and 3 in. long. Both models are suitable for a wide range of applications. Photocircuits Corp., 31 Sea Cliff Ave., Glen Cove, N. Y.

Circle 646 on Page 19

Midget Bearing

self-aligning unit is for fractional-horsepower motors

Series 0049 self-aligning bearing available for shaft sizes of ½, 5/16, ½, and 7/16., is a self-contained, permanently lubricated bearing with a sintered-bronze bushing. De-



signed for small fractional-horsepower motors, it is maintenance-free and eliminates the need for oil lines, reservoirs, oil cups, wicking, oil slingers, and catchers. Randall Graphite Bearings Inc., Greenlawn Avenue, Lima, Ohio.

Circle 647 on Page 19

Microminiature Connectors

have up to 7 contacts in ½-in. diam

Snap-E-Lock Series 4A microminiature connectors feature up to 7 contacts within ½-in. diam. Sockets are closed-entry type. Waterproof connectors provide resistance to high breakdown voltages. Positive locking is accomplished by the use of a lockband which latches automatically when connector is engaged. Connector is available with 2, 3, 4, 5, and 7 contacts, in a variety of



mounting styles and in glass-seal types. Viking Industries Inc., 21343 Roscoe Blvd., Canoga Park, Calif.

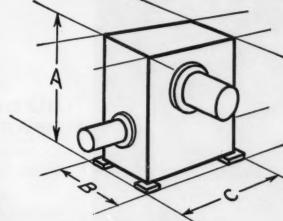
Circle 648 on Page 19

Fabricated Aluminum

for grillwork in a variety of applications

AL-dec fabricated aluminum functional and decorative grillwork is available in a variety of patterns and colors. Extremely flexible, it has applications in household appliances, exterior and interior construction, air conditioning, air-handling units in heating and ventilat-

Do-It-Yourself...



Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You

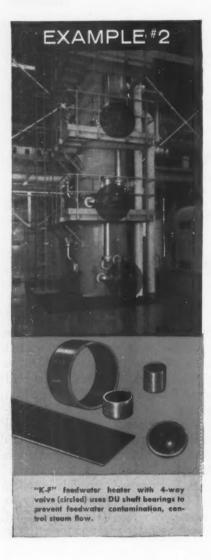
can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the tearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.



DU*DRY BEARINGS

Solve Another Problem

"Only DU material was successful in our new 4-Way Plug Valve Shaft Bearings after four or five of the more conventional bearing materials failed to pass acceptance tests."

J. B. Stevens, Mgr.
Valve Sales & Engineering
Schutte & Koerting

Four-way valves with DU bearings were used in an entirely new approach to a boiler feedwater heating system developed by the Kuljian Corp., applied by Cochrane Corp., and now installed in prototype unit at the Borough of Lansdale (Pa.) Municipal Power Plant. Du bearings contributed to reported appreciable savings per kw installed capacity by elimination of feedwater contamination, reduction of bypass leakage and resistance to the 400°F operating temperatures.

DU metal is an ideal bearing material for many applications. It withstands much higher velocities, runs much cooler at lower speeds than other unlubricated bearings . . . has a compressive strength of 51,000 p.s.i. DU metal is applied without the need for temperature-limiting adhesives . . . will withstand from -328°F to +536°F.

GARLOCK

Apply DU dry bearings to appliances, automobiles, aircraft, farm and industrial machinery, office equipment. Standard bushings and thrust washers available for ½" to 2" shafts; strip available for special fabrication. Write for engineering catalog DU-458. Special Products Dept., United States Gasket Company, Plastics Division

of The Garlock Packing Company, Camden 1, New Jersey. *Trademark, Glader Metal Company Ltd.



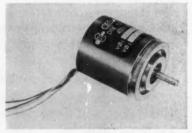
ing, and automotive uses. Material is available in maximum lengths of 21 ft and widths to 12 in. Because of the over-all symmetrical pattern, sections fastened side-by-side give the effect of a continuous screen or grille of any desired size. Bohn Aluminum & Brass Corp., 1400 Lafayette Bldg., Detroit 26, Mich.

Circle 649 on Page 19

Servo Motor

has all-plastic body

Integrally cast in thermosetting epoxy resin, size 11 servo motor is impervious to salt spray and corrosive fluids, and offers high resistance to physical shock. Standard servo-motor mounts are available in addition to Model R2404, shown, which uses an O-ring mounting to



seal motor and gear train from coolant fluids or gases in applications where the unit is immersed. Ambient temperature range is -55 to +71 C. Cedar Engineering Div., Control Data Corp., 5806 W. 36th St., Minneapolis 16, Minn.

Circle 650 on Page 19

Microminiature Rivets

for electronic and instrument uses

Microminiature rivet-type fastener combines advantages of both solid and tubular-rivet styles in a concentrically deep-drilled shank, providing the ease of setting necessary in small or delicate assemblies. Solid upper portion of rivet contributes rigidity and prevents buckling or bending in the upsetting or clinching operation. Drilled section controls material flow and accomplishes an effective clinch with a minimum of pressure on parts or material being assembled. Material is specification nonmagnetic brass with the alloy



controlled to insure setting ease and uniformity of the swaged or upset clinch. Standard 24-carat-gold electroplated and shot-burnished finish resists severe environments, and provides excellent electrical contact. Full line of lengths is available in fractional increments of 1/32-in. in each fractional diameter down to 1/32 in. Circon Component Corp., Santa Barbara Municipal Airport, Goleta, Calif.

Circle 651 on Page 19

Plastic Jacketed Cables

are available in standard color shades

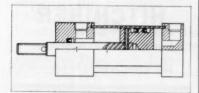
Color-coded plastic jackets permit quick identification of cables connecting the units of electronic equipment as to function and circuit before, during, and after installation. Cables in standard-color plastic jackets are available with any size and number of conductors. Lenz Electric Mfg. Co., 1751 N. Western Ave., Chicago 47, Ill.

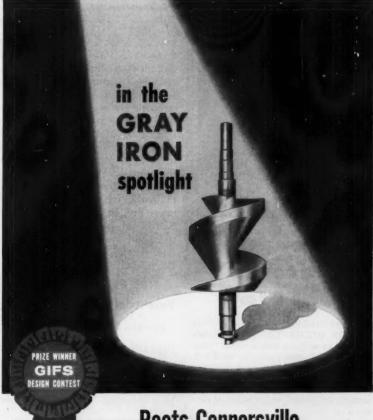
Circle 652 on Page 19

Midget Cylinders

have reduced piston-rod end diameter

Redesigned midget air and hydraulic cylinders combine the advantages of Block Vee sealing and greater bearing length. All models feature two dynamic packings on the piston and one on the rod gland. High-pressure end-cover seals are Buna-N O-rings. Aluminum pistons provide 1 in. of bearing length against tube walls. Piston rods are





Roots-Connersville
Achieves 29% Cost Reduction
with Integral Rotor and Shaft

The exceptional design freedom in the gray iron casting process frequently enables the designer to reduce costs by converting multiple piece assemblies into one part. Roots-Connersville recently achieved noteworthy savings by redesigning forged steel shafts onto which were pressed ductile iron rotors into a one piece cast part.

Since the rotor hub formerly had to be large enough to key it to the shaft, the redesign results in 41% greater displacement by permitting smaller hub diameters and correspondingly larger outside diameters in the same housing. Machining was reduced from 27 operations to 15.

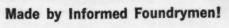
Start now to re-evaluate your products in the light of integral gray iron castings. Use the experience and know-how of progressive foundrymen, members of Gray Iron Founders' Society, to help achieve outstanding savings.

FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.



GRAY IRON CASTINGS







Kerosene, Jets & **Fuel Flow**

Spectrol developed its newest PRECI-SION MECHANISM—A Pulse Totalizer-for an airborne system which measures fuel flow with particular accuracy. But this carefully-designed electromechanical counter has many uses. You can apply it to any sort of pulse counting scheme, airborne or ground, where electrical output is required.

The Totalizer features 5 decade switches, each having a string of precision resistors to give electrical readout. It also has a built-in amplifier which makes the input interesting-20 volts into 10K impedance. Operating from dc power, the unit will count up to 15 counts per second. There's a manual reset and, as you can see, visual readout.

How It's Used. The Pulse Totalizer is part of a fuel measuring system aboard a jet airliner. A flowmeter acts as a transducer, and an amplifier delivers pulses proportional to the number of gallons to the Pulse Totalizer. The output from the Totalizer is delivered to multi-channel recorders as an indication of how much fuel was consumed per unit time. The visual readout feature of the Totalizer also permits its use on a photo panel aboard the aircraft for studies of fuel flow rate and total consumption.

This is another example of how Spectrol PRECISION MECHANISMS free the systems engineer from building functional subassemblies. If you need modules using components such as gear drives, clutches, precision potentiometers and servomotors -Spectrol can help.

For more details, call your Spectrol engineering sales representative, or address Dept. 63.



ELECTRONICS CORPORATION 1704 South Del Mar Ave. . San Gabriel, Calif. stainless steel, 3/8 in. diam, and are threaded 5/16-24 for all models. Cylinders are furnished in 3/4, 1, and 11/8-in. bores. Lengths are in 1-in. increments, but fractional increments are available by the addition of spacer bushings on the next larger size. Mark A series is for 200 psi air and 750 psi oil, and Mark H is for 2000 psi oil. Units operate continuously at ambient temperatures from 40 to +180 F, and intermittently, for one minute out of every five, at temperatures to 200 Ten heavy-duty mounting styles are available. Control Line Equipment, 19560 Center Ridge Rd., Cleveland 16, Ohio.

Circle 653 on Page 19

Vane-Axial Blower

provides high output

Type GR vane-axial blower operates on 115 v ac, 60 cps, and delivers 220 cfm of air at 1.75 in. water static pressure and 315 cfm at 0 in. back pressure. Maximum current



at free air delivery is 1.8 amp, and speed is 8000 rpm. Unit is housed in a precision-cast, black anodizedaluminum enclosure and meets MIL specs. Blower measures 43/4 in. in diam and is 63/8 in. long; weight is approximately 4.5 lb. Mounting is made with six bolts to the front flange. Unit can also be operated on dc power since a universal motor is employed. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle 654 on Page 19

Steel Fitting

for nylon and other plastic tubing

Self-Lock steel fitting is well adapted to hydraulic and pneumatic power systems, lubrication systems, instrumentation, and chemical proc-



These roller mounts, used on a precision skin-grafting machine, guide rollers which regulate the depth of the skin graft. The material used must withstand the high temperature of sterilizing and the corrosive elements of human blood.

The user of these stainless steel roller mounts once thought they could only be made by machining of stainless steel bar stock. Hitchiner's "Engineered Quotation" showed they could be investment cast, not only in the necessary alloy and without design changes, but with considerable savings.

The use of investment casting meant five times greater production without highly-skilled labor, a one-per-thousand reject rate, and a per unit cost of a third that of machined parts.

This wide freedom of choice in alloy, as well as flexibility in design may help you with your parts manufacturing problems. Try "the Hitchiner way" yourself and send us a sample or blueprint for our "engineered quotation" - no obligation.



Find out how our new ceramic shell technique can possibly benefit you. Send for our free, new revised brochure on the latest investment casting methods.

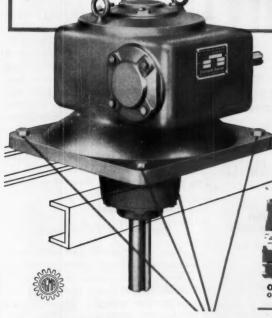
HITCHINER

MANUFACTURING COMPANY INC. MILFORD 26, NEW HAMPSHIRE

Coast to Coast Engineering Representatives

FAST off-the-shelf delivery

MORSE EBERHARDT-DENVER CONVEYOR DRIVES



 \star No design limitation . . . up, down, or 90° mounting \star one-piece alloy cast iron housing \star high torque capacity \star single or double reduction gears \star input ratings from .12 hp to 53.72 hp using double worm reduction or helical worm reduction \star ratios from 5:1 up to 3600:1—from stock at low factory prices.



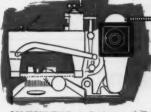
SUB-FLOOR ... for towline or special equipment

Easy-mount design...only 4 bolts

Morse E-D speed reducers lead in limitless applications with utmost ease in mounting. The 4 holes form a perfect square concentric to the output shaft. Unlike most designs, Morse E-D speed reducers feature oversize bearings on wide centers...resulting in an overhung load capacity at the end of the output shaft equal to the torque capacity.

Mounting versatility with the unit's cast-in base makes Morse drives adaptable to conveyors of all types, agitators, screw conveyors, machines, and for any other transmission of power where dependable speed reduction is specified.

You'll find Morse "standard" drives ready for immediate delivery... often eliminate the problems of "specials." Check with your Morse distributor, he's listed in the Yellow Pages under "Power Transmission," or write Morse Chain Company, Dept. 6-40, Ithaca, N. Y. for illustrated catalogs. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.



90° MOUNTING ... for heavy-duty



VERTICAL . . . base mounting for power turntable machines



SIDE MOUNTED . . . paint, pulp, liquid, or chemical agitators



HORIZONTAL . . . screw conveyors, straight or angular mounts . . . and scores of standard or special uses.



A BORG-WARNER INDUSTRY



One word explains the popularity of these switches...

Dependability

Denison LOXSWITCH Limit Switches operate with the dependability of Old Faithful. Oil- and dust-tight features, superior electrical characteristics and mechanical design result in three to five times longer life than comparable switches.



L100W HEAVY DUTY LIMIT SWITCH

- 45 CIRCUIT ARRANGEMENTS.
- LONGEST CONTACT LIFE due to lowest impact of 2.5 grams and minimum "bounce".
- WATER-, DUST- AMD OIL-TIGHT, NEMA 12.
- ONLY FOUR MOVING PARTS.
 Longer life, easier to maintain.
- 70° SAFETY OVERTRAVEL without use of extra springs or cams.
- OVER 150 LEVER STYLES.

MODEL M PRECISION LIMIT SWITCH

- LONG MECHANICAL LIFE nylon latch mechanism.
- 600 VOLT INDUSTRIAL CONTROL RATING.
- · COMPLETELY ISOLATED CIRCUITS.
- 6º TRIP DIFFERENTIAL,
 50º overtravel in both directions.
- PRECISION REPEATABILITY ± .001".
- WATER-, OIL-, DUST-TIGHT NEMA 12.
- FULLY INTERCHANGEABLE with thousands of existing layouts.



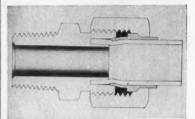
BOTH MODELS AVAILABLE WITH PLUG-IN CONVENIENCE

Write for literature describing our complete line.

Address R. B. DENISON MFG. CO., 386 Broadway, Bedford, Ohio

DENISON LOXSWITCH

Wire with LOXSWITCH and you wire for good!



essing. It is available for thin and heavy-wall nylon tube, and for other plastic tubing. Fitting is furnished in all commercial shapes and sizes in steel, brass, aluminum, and stainless steel. Internal tube support prevents collapse of tube wall as fitting is tightened. Precision sleeve with collet fingers grip outside of tube, holding it securely in position. Fitting is reusable indefinitely. Flodar Corp., 16911 St. Clair Ave., Cleveland, Ohio.

Circle 655 on Page 19

Solenoid Valves

have molded Teflon bodies

Line of chemically inert, corrosionresistant solenoid valves are shockresistant and pressureproof. Valves, with molded Teflon bodies, are suitable for critically corrosive and abrasive applications where complete dependability is essential.



Valves are designed for normally closed applications in all normal ac and dc voltages. Valcor Engineering Corp., 365 Carnegie Ave., Kenilworth, N. J.

Circle 656 on Page 19

Precision Thermostat

opens or closes on temperature rise

Low-differential precision thermostat, designated Klixon 4286, is designed for electronic heating or

Captive Quick-Opening Fasteners:

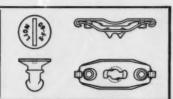
Southco standards provide many benefits at low cost for access through doors, covers, panels and into drawers



LION 1/4 TURN FASTENERS

Quick, positive locking, by fractional turn. Tight seal formed by compression of leaf spring. Alignment and stack height not critical. Approved for aircraft use. Rugged. Extra strength provided by swaged nose. Vibration resistant.



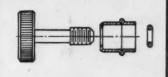




RETRACTABLE SCREW FASTENERS

Stand-off thumb screws from stock to eliminate costly, special fasteners. Installed quickly without special tools. Accommodate misalignment. Complete range of standard sizes.



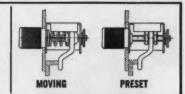




ADJUSTABLE PAWL FASTENERS

Pre-assembled, quickly installed. Accommodate variations in frame thickness up to ½ inch. One-quarter turn closes, additional turns increase grip pressure. Attractive appearance, long life. Moving or pre-set pawl. Miniature, intermediate and large sizes.



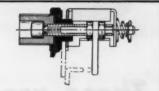




ADJUSTABLE PAWL FASTENER

Has twin-knob control. One knob controls pawl, pointer shows pawl position. Other knob controls amount of pressure to seal closure with uniform pre-set compression. Easily installed.

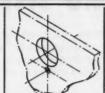


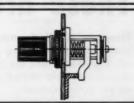




ADJUSTABLE PAWL FASTENER

Compact and rugged. Eliminates rivets or bolts to save installation time. Three types cover grip range up to ¾". Supplied either with integral metal and plastic knob, plastic knob or for your knob.



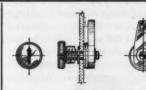




ARROWHEAD DOOR LATCH

Requires only one hole to install. Operates on quarter turn. Holds under spring tension. Arrow shows pawl position; no pawl stops required. Uses minimum inside space.







Send for your complete Southco Fastener Handbook, just printed. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.







These are no sissies!

They are AE Hydramite® pumps, the heavy-duty hydraulic pumps that start delivering where other "heavy-duty" pumps leave off. Check into them for the tough jobs where you want sheer stamina...the jobs where extra reliability and sustained performance are an urgent requirement.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 25 gpm at 5,000 psi and 60 to 100 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100°F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100°F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles.

Write or call American Engineering Company, Dept. P-147, Philadelphia 37, Pa. Phone: CUmberland 9-3800.

See our four-page catalog in Sweet's Product Design File, or write us for reprint (Catalog P-60).

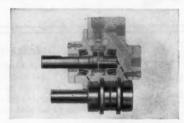


AMERICAN ENGINEERING COMPANY

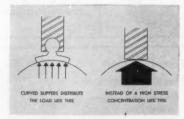
Division of United Industrial Corporation

Hele-Shaw® Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries,

Vibra-Grate, Perfect Spread and Taylor Stokers.



Tapered roller bearings. High-capacity, heavy-duty tapered roller bearings support the eccentric cam shaft. This means that a Hydramite can take more punishment... handle heavier unbalanced loads... and last longer.



Curved Slipper distributes thrust load of the plungers and reduces unit stress to the point where maintenance is never required at what is a critical wear spot in most hydraulic pumps.

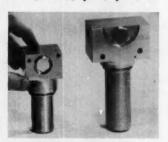


cooling applications. Unit opens or closes on temperature rise and has a high capacity. Thermal coupling between case and temperature-sensitive element allows fast temperature response. Snap-acting disc is electrically insulated and attached to the cup. Continuous temperature-exposure limits are -65 to +270 F. Series handles momentary overrides to 325 F on types designed to open on temperature rise, and overrides to 320 F on types that close on temperature rise. Temperature setting range is 0 to +250 F. All models resist 60 g shock. Metals & Controls Div., Texas Instruments Inc., 34 Forest St. Attleboro, Mass. Circle 557 on Page 19

Hydraulic Filters

are compact and lightweight

Two high-pressure airborne hydraulic filters, rated at 3.6 gpm and 10 gpm, contain filter elements made from pleated, resin-impregnated cellulose fiber sheet. Both assemblies have a pressure drop of 30 psig at their respective flow rates using MIL-H-5606 fluid at 100 ±10 F. They have temperature ratings from -65 to +275 F. Rated operating pressure for both assemblies is 3000 psi with a rated impulse burst pressure of 7500 psi. The 10-gpm assembly weighs 1.3 lb and has AND 10050-10 porting. The 3.5-gpm unit weighs 0.7 lb and has AND 10050-6 porting. Filters are also used for aviation gasoline, kerosene, RP-1, JP-4, JP-5, S-45,





Why "MARK-TIME" MECHANICAL TIMERS should be INVESTIGATED!

Low cost mechanical Timers, Time Switches and Time Devices can be quite sophisticated. For example: they can be designed to ring bells, flash lights, turn valves, cut cords, start, stop or operate electrical or mechanical equipment, and to do all this after a pre-selected time period has elapsed.

The "Mark-Time" mechanical "memory" cannot fail due to an electrical failure since it is spring powered.

The "HEART" of the "Mark-Time" is of a new super-tough alloy which prolongs mainspring life indefinitely.

This new special steel virtually eliminates mainspring failure. This adds extra sales features to your product at no extra cost.

The "MARK-TIME" Mainspring is Unbreakable!

Tensile strength, durability and corrosive resistance is unexcelled. No other Timer on the market has these exclusive features.

At present, we manufacture more than 3,000 DIFFERENT kinds of custom-built timers for industrial, consumer and military applications. Thus, we are the largest manufacturer of mechanical timers in the world!

Research and development work welcome—small runs our specialty. Sales engineers in 27 key cities at your service.

Write for your copy of this new Engineering Handbook on Timers, specifically written and illustrated for the Design and Development Engineer.





Skydrol 500, Oronite 8515, water, acetone, trichlorethylene, petroleum ether, alcohol, air, gaseous oxygen, gaseous nitrogen, helium, MIL-L-7808, lubrication oils, and other related fluids. Bendix Filter Div., Bendix Aviation Corp. 434 W. 12 Mile Rd., Madison Heights, Mich.

Digital Readout

miniature unit displays words and color

Series 120000 miniaturized digital readout is designed for use with digital computers, control equip-



ment, instruments, airborne equipment, production and inventory controls, and other electronic or electrical test equipment. It permits display of words and other information such as temperature, humidity, and pressure on the front viewing screen. In addition, red, orange, yellow, green, or blue colors can be displayed on the screen, either by themselves or as background for digits, words, or messages. Readout operates on a rear projection principle. Light source comes from subminiature lamps. Character displayed on front viewing screen is 5/8 in. high. Unit is 3-7/8 in. long, 1 in. wide, and 1-5/16 in. high, and weighs 31/2 oz. Industrial Electronic Engineers Inc., 5528 Vineland Ave., North Hollywood, Calif.

Circle 659 on Page 19

Self-Locking Nut

clip-on unit replaces standard nutplate

Self-locking, clip-on nut is applied where suitable edge margin exists or through cutout hole in center of



panel. Designed to replace standard nutplates, it quickly slips onto panel or structure and locks firmly in bolt hole. Nut is available for 0.020 to 0.150-in. application thickness. Unit meets MIL-N-25027, 120,000-psi class. Monadnock Mills, San Leandro, Calif.

Circle 660 on Page 19

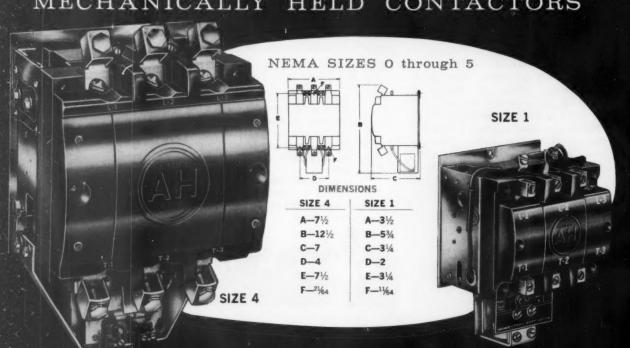
Fluorocarbon Rubber Parts

Kel-F temperature limit increased from 85 to 200 C

A special peroxide cure used with Kel-F 3700 halofluorocarbon elastomer increases temperature performance maximum from 85 to 200 C without reducing resistance qualities. Components made of the peroxide-cured elastomer exhibit

ARROW (AH) HART

MECHANICALLY HELD CONTACTORS



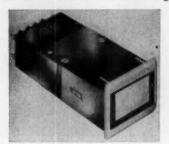
are impervious to corrosion. Applications include high-temperature electric insulation, and as hose seals, diaphragms, fuel cells and systems using fuming nitric acids and fuels of the JP4 and JP5 types. Vernay Laboratories Inc., Yellow Springs, Ohio.

Circle 661 on Page 19

Switch Light

rebulbs from front

Reliable switch light has all terminals at back of assembly so 115 v ac AN-3140-327 bulbs can be inserted from front without tools. Lamp and switch circuits are independently operated. Lens area can be subdivided into four seg-



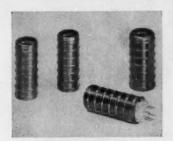
ments. Units are easily wired, and mount flush. Units and switches are qualified per MIL specifications and have solid shake-proof mounting with impact-resistant construction. Bulbs remain stationary during switching. Having bright, uniform light intensity, units may be grouped with standard Roto-Tellite units. Ambient temperature, -65 to +160 F. Master Specialties Co., 956 East 108th St., Los Angeles, Calif.

Circle 662 on Page 19

Zinc-Plated Shield

for miniature 7 and 9-pin electron tubes

Zinc-plated Mini-Shield, finished in black, provides excellent heat dissipation. It increases the reliability and prolongs the life of miniature 7 and 9-pin electron tubes by as much as five times, reducing heat by as much as 5 C. Unit holds miniature tube firmly in its socket with a grip that tightens against any force that tends to loosen tube. Vertical seam automatically adjusts to proper tube diameter, and four



serrations on base-clip prongs compensate for tube-length variations. Staver Co., 49-51 N. Saxon Ave., Bay Shore, L. I., N. Y.

Circle 663 on Page 19

Teflon-Lined Hose

withstands almost all chemicals

Flexion Teflon-lined hose has very low permeability and zero water absorption. It withstands all known chemicals except fluorine gas, chlorine trifluoride, and molten alkali metals. Construction features bonding of glossy Teflon tube to hose body, eliminating separation, crack-

MOTOR CONTROLS

ONE/HALF

THE SIZE AND WEIGHT of CONVENTIONAL CONTROLS!
WITH ADVANTAGES ONLY "RA" DESIGN CAN OFFER

Arrow-Hart now offers Mechanically Held Contactors with or without coil clearing contacts, in NEMA Sizes 0-5, as well as its complete line of "Right Angle" design contactors. Applications include machine tool control circuits and electric furnaces requiring continuity of operating sequence despite voltage failure or interruption. Also widely used in locations where quiet is essential and where the hum characteristic of a-c magnets in an electrical holding circuit is objectionable.

MECHANICALLY HELD OR STANDARD CONTACTORS OFFER:

- Small Size
- Straight-thru Front Wiring
- Improved Performance & Dependability
- Greater Magnet Efficiency . . . control transformers up to 1/4 smaller
- Easy to Add Auxiliary Interlocks
- Less Weight
- Easy Inspection, Installation, Maintenance
- Vertical Contacts... prevent accumulation of breakdown materials
- Pressure Lugs Sizes 1 thru 5
- · Hard Epoxy Coils

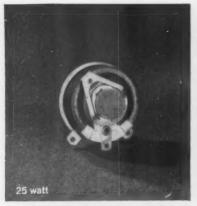
Write today for details to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn St., Hartford 6, Connecticut

ARROW-HART of HARTFORD

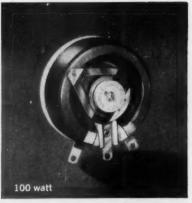
Quality since 1890

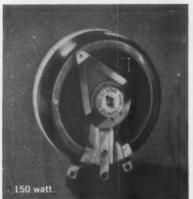
MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES • WIRING DEVICES

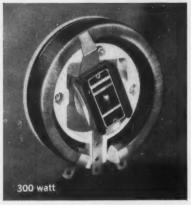
Circle 515 on Page 19





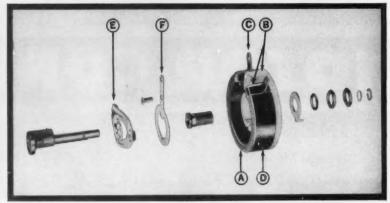












From 25 to 300 watts these VITROHM ring rheostats are engineered for longest life, maximum reliability

To be sure about smooth, trouble-free control in the 25- to 300- watt rangejust specify a VITROHM rheostat.

You get smooth control: Close-laid turns (A) of special high-stability, lowtemperature-coefficient wire or ribbon to insure smooth gradual resistance change from zero to maximum.

You get reliability: VITROHM ring rheostats are engineered for permanence from highest-grade ceramic base and core (B), durably bonded, tinned-alloy terminals (C), to final craze-proof, shock resistant, long-lasting VITROHM bonding (D).

You get positive action: Self-lubricating twin-shoe contacts-exclusive with W/L-on balanced beryillium copper contact arm (E) eliminate backlash, contribute to smooth operation, minimize wear on resistance wire (A), assure positive contact to collector ring (F).

You get many more features than we can detail here. Check them all in W/L Bulletin 60RR (and, above 300 watts, check "plate rheostats" in Bulletin 60A). Either bulletin, yours for the asking. Ward Leonard Electric Co., 58 South St., Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) 9.6

Write for list of stocking distributors



WARD LEONARD

ELECTRIC COMPANY

MOUNT VERNON, NEW YORK

LIVE BETTER ... Electrically

Result-Engineered Controls Since 1892













ing, or splitting, even with small bending radii. Plies of high-tensile cotton cords or special braided steel wire form the strength members, securely bonded to tube and heavyduty cover. Temperatures to 325 F and working pressures to 1500 psi are acceptable, depending on size and type of hose. Hose is available in diameters to $1\frac{1}{4}$ in. in 15 to 50-ft lengths, with brass or stainless-steel fittings. Manhattan Rubber Div., Raybestos-Manhattan Inc., Passaic, N. J.

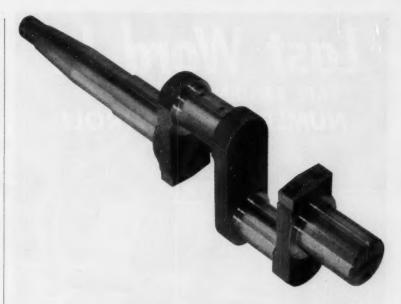
Circle 664 on Page 19

Adjustable-Speed Drives

feature unit construction and compact controls

Adjustable-speed ac drives, called Magnaflow, have integral-unit construction, and are rated from 1/4 to 100 hp. Larger drives with separate motor mounted on a bedplate are offered up to 700 hp liquid cooled. Simple control modifications to provide a variety of speed operating functions are also available. The Magnaflow electromagnetic drive applies adjustable speed power to conveyors, fans, and pumps winders and metal slitting and forming machines. The drive can be set before or during operation to deliver any desired speed within its range. A built-in tachometer monitors the output speed and automatically corrects it, regardless of any change in load. Each drive operates on ac power. There are no brushes, com-





RIGIDITY

A CASE IN POINT—This seventy pound ductile iron crankshaft is made for compressors manufactured by The Brunner Division of Dunham-Bush, Inc. The increased loads and speeds called for by new compressor design specifications required rigidity and strength beyond the limits of the cast iron alloy shafts formerly used. Ductile iron was chosen because the rigidity, tensile strength, fatigue strength and wear characteristics comfortably exceed operating requirements. A major bonus—the existing pattern equipment could be used for the ductile iron castings, thus saving the high cost of dies needed for steel forgings.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures as gray iron. The 120-90-02 grade used in this case has an elastic modulus of about 24 x 106 psi, 42,000 psi endurance limit, and 300 BHN. The 120,000 psi tensile strength is double that of the previous crankshaft. Hamilton Foundry regularly casts all grades of ductile iron and high alloy Ductile Ni-Resist.

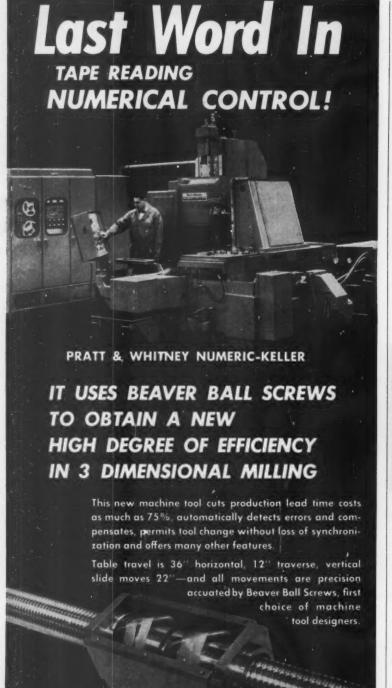
When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON . ALLOYED IRON . MEEHANITE® . DUCTILE (NUMULAR) IRON . NI-RESIST . DUCTILE NI-RESIST . NI-HARD



HAMILTON FOUNDRY

1551 LINCOLN AVENUE . HAMILTON, OHIO . TWINDrook 5-7491

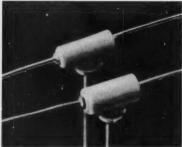


mutators, or slip rings to maintain. In addition, there are no friction members to wear, replace or adjust. Standard excitation and regulator control for air-cooled drives up to 30 hp measures only 93/4 x 81/4 x 241/2 in. Control units provide speed regulation accurate within 2 per cent of top speed. Magnaflow drives are adaptable to either electronic or magnetic amplifier excitation control. Modifications are available for electromagnetic braking, inching, threading, torque control, controlled acceleration, multidrive control, and constant tension for winding. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 665 on Page 19

Tantalum Capacitors

two small sizes provide up to 3 fm capacitance



Two new sizes have been added to Series TW line of tantalum wire electrolytic capacitors. Size TK, the smallest, is only 0.150 in. long and 0.060 in. in diam, yet provides up to 2 mf capacitance. Size HK is the same length, 0.075 in. in diam, and provides up to 3 mf ca-Capacitors feature a pacitance. tantalum-wire anode in a silvercase cathode. Mylar sleeving is used as insulation. Ohmite Mfg. Co., 3640 Howard St., Skokie, Ill. Circle 666 on Page 19

Pillow-Block Bearings

are completely cushioned

Pillow-block bearings for applications requiring effective noise and vibration suppression are available in shaft sizes from $\frac{3}{4}$ to $\frac{1}{4}$ in. inclusive. NB series is self-aligning and has a large oil reservoir to insure long life. Cushion, which completely encircles bearing-ball unit

Can our engineers help you obtain

- (1) greater accuracy in positioning
- (2) minimum break-away friction
- (3) greater system stiffness

Beaver engineers are ready to work with you on your actuating problem.



ONLY SQUARE D STARTERS WITH ONE-PIECE OVERLOAD RELAYS **GIVE ABSOLUTE PROTECTION!**

 Only Square D makes thermal overload relays with 1-piece construction-and only with 1-piece construction can you know you've installed the heater correctly. Square D 1-piece overload relays can be installed only one way. They are factory-assembled, individually tested and calibrated, completely tamper-proof. Repeated tripping will not affect accuracy.

You pay for overload protection be sure you get it. Insist on Square D 1-piece overload relays for absolute protection.



Mail coupon today for simple 'jig-saw' demonstrator e why only Square D gives absolute protection



is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.



Department SA-233 4041 North Richards Street Milwaukee 12, Wisconsin

Please send me information on Square D magnetic starters, along with your simple 3-minute "jig-saw" demonstrator

COMPANY. ADDRESS.

ZONE STATE



COMPANY

wherever electricity is distributed and controlled



to insulate it from the mounting, is 50-durometer Neoprene. Triangle Mfg. Co., 700 Division St., Oskosh, Wis.

Circle 667 on Page 19

Hydraulic Packing Material

for both acid and alkaline applications

Rex-Syn packing material combines a plastic and an elastomer to produce a material which is highly resistant to abrasion and which can be used in both acid and alkaline applications. Tensile strength of the compound is over 3000 psi, making it suitable for relatively highpressure applications. Material seals effectively in air, oil, water, and water-based, fire-resistant hydraulic media. Operating temperature range is 0 to 212 F. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

Circle 668 on Page 19

Cable-Clamp Assembly

permits direct application to endbell

New cable-clamp accessory is for use in conjunction with MS-R and MS-E (CT Series) plugs. Available in a variety of sizes, it is sold separately from the plugs. Clamp and pins, of nonmagnetic stainless steel, permit direct application to the endbell in lieu of grounding screws. If grounding is required, ground solder lugs can be placed under the adapter instead of the regular lockwasher. Captive clinch nut and screws are also steel with cadmium

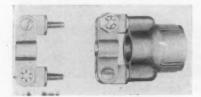


plate to give all parts a "white" appearance. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Circle 669 on Page 19

Quick-Release Fastener

has strength of a standard bolt

Cam-Bolt, for use where the strength of a bolt is required but where fast opening and closing is desirable, maintains a constant, leakproof seal of any predetermined pressure. Single adjustment made at the time of installation insures proper sealing pressure. Device is instantly and easily locked and released by a quarter-turn. Shear and tensile-load ratings are equal to those of a standard bolt. Cam-



Bolt is infinitely adjustable to any predetermined torque. Spring does not carry load, but serves to hold stud in position during locking and unlocking. Fastener is available in ½ and ¾-in. diam sizes. Simmons Fastener Corp., North Broadway, Albany 1, N. Y.

Circle 670 on Page 19

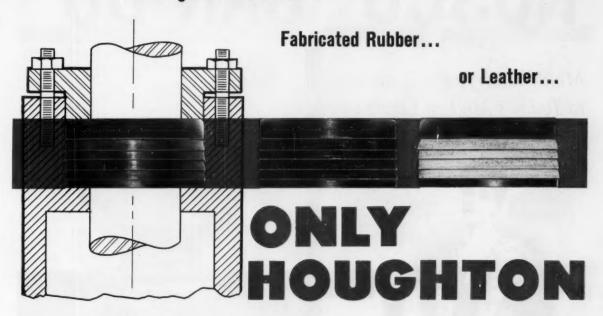
Tube Fitting

connects copper, plastic, or aluminum tubing

Fast-Tite OD-type fitting connects copper, plastic, or aluminum tubing in 2 sec. Connections are made without clamps required with an insert-type fitting as used with plastic pipe, and without the necessity of flaring, belling, or soldering as is done in connecting metal tubing. Tube is inserted in the fitting with a twisting motion as far as it will go, providing a positive connection leakproof for vacuum, gases, and fluids over a wide range of pressures and temperatures. Positive seal is accomplished through use



Homogeneous Rubber...



makes "V" Packings interchangeable to meet JIC standards

Standard stack height of all Houghton "V" packings gives you an advantage no other manufacturer can match. Whether you use homogeneous rubber, fabricated rubber or leather "V's" . . . Houghton packings are interchangeable . . . meet JIC standards and fit every time.

Leadership in packings standardization is another reason major hydraulic and pneumatic equipment manufacturers consider Houghton "packing headquarters". Houghton is also the only manufacturer who offers a complete line of packings and fluids for almost any industrial hydraulic system. This experience in both fields is your guarantee of a completely unbiased recommendation of compatible materials . . . the very best for your particular application.

For more information or help, call or write: E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Penna.

Call your Houghton Man for authoritative design and engineering help on any packing or moulded rubber part problem.



Industry's Partner in Production

E HOUGHTON & CO.

Philadelphia, Pa. . Chicago, III. . Carrellton, Ga.

Detroit, Mich. . San Francisco, Calif. . Toronto, Canada

NOSCO "CAN DO"

Molds Yesteryear's Traditions to Today's Modern Living . . .



Automatic Packaging is Bonus of "Can Do" Service...



Time honored products are a favorite victim of changes in tastes and living habits. Wyeth Laboratories learned that about their traditional transparent blue glass eye cup. That's why turned to Nosco "Can Do."

The glass eye cup was an almost priceless symbol—backed by years of advertising and consumer acceptance. But it needed styling refinements to achieve a more modern cosmetic look. And could it be more durable to withstand the abuse of smaller, overcrowded medicine cabinets and possible falls on harder floors?

Nosco said "Can Do." The new molded plastic cup preserves identity by being an exact color match and retaining the basic lines. But Nosco's engineering know-how refined the style to give a more delicate appearance while actually



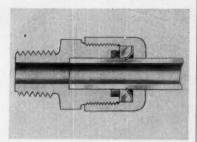
increasing shock resistance. And unit price was held down by Nosco volume production—20,000 eye cups in a single 24-hour day.

But that wasn't all. Nosco "Can Do" means more than just engineering and production skills. It means complete service, complete facilities. Wyeth gains an added plus from this. Nosco automatically packages each eye cup in an individual plastic bag immediately after molding, thereby preserving its sterile qualities.

thereby preserving its sterile qualities.

Does new competition have an advantage over your time honored product or package? Nosco can retain your traditions, while giving you the benefits of modern, lightweight plastics. For quality-controlled plastic products—either injection or blow-molded—contact the competent Nosco representative near you.

NOSCO plastics, inc. • erie 2, pa. One of the world's great injection molders.



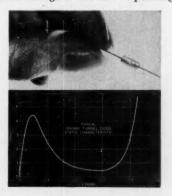
of a lifetime O-ring seal which is partially embedded within the fitting. Serrated spring-steel ring, positioned ahead of the O-ring seal, bites slightly into outer tube surface to give the fitting exceptional strength when tube and fitting are placed in tension. When installed, fitting can be turned a full 360 deg without lessening effectiveness of seal or reducing grip of fitting on tube. Fittings are nontoxic nylon, Cycolac, or polypropylene resins. Threads are standard IPS connectors available for use with standard tubing from 1/4 to 2 in.; either male or female threads. D & G Plastics Co., Kent, Ohio.

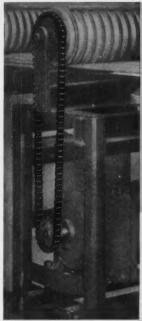
Circle 671 on Page 19

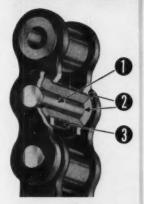
Tunnel Diodes

with peak currents from 0.8 to 20 ma

Sample quantities of types T101-T105 germanium tunnel diodes, with peak currents ranging from 0.8 to 20 ma, have peak to valley current ratios in excess of 5 to 1, and more typically 8 to 1. Offering inherent design advantages of small size, reliability, radiation-resistance, wide temperature range and high cutoff frequency, they have a typical peak-point voltage of 50 mv and typical valley-point voltage of 250 mv. Operating







Built-in Lubrication at these 3 Critical Areas

Critical Area 1:

PIN—Protective oil film lubricates live bearing area between pin and bushing, minimizing wear by reducing metal-tometal contact.

Critical Area 2:

PLATES—Oil-impregnated Sintered Steel Bushings extend beyond surface of inside plates to: act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate gailing and seizing frequently caused by misalignment of sprockets.

Critical Area 3:

SPROCKET ENGAGEMENT—Oil film on MSL Bushing exterior provides constant lubrication between sprocket teeth and chain. Whitney MSL Chain requires no rollers, as the tough oil film on the bushing surface provides smooth bushing surface provides smooth sprocket engagement, cushions impact and reduces drive wear.



For POWER-CURVE'S

Power Curve's Bag and Package Loader works like a mechanical stevedore in high speed loading of box cars and trucks. The chain drives which shuttle and power this flexible conveyor must have plenty of stamina to withstand continuous shock loads from delivering chutes, and to propel loads in and out of cars.

To provide greater drive chain durability, Power-Curve engineers rely exclusively on Whitney MSL Self-Lubricating Chain.

The basic problem in chain operation has always been that more damage is caused by faulty chain lubrication at the 3 critical areas, than by years of normal service. Whitney Research has solved this problem through the development of a lubricated-for-life chain that outlasts ordinary chain as much as 5 to 1.

Oil-impregnated, Sintered Steel Bushings release a constant supply of lubricant under pressure and heat...re-absorb the oil when the drive stops...insure a permanent oil supply for the life of the chain.

For exceptional drive chain performance, long life, and for sure resistance to dust, dirt and other abrasives, specify and use Whitney MSL Chain. All essential dimensions conform fully to ASA Standards for complete interchangeability with any similar pitch chain.

Your Whitney Chain Distributor has a complete stock on hand, ready for immediate delivery. Consult him today.

* Maximum Service Life

THE WHITNEY

a subsidiary of FOOTE BROS. GEAR AND MACHINE CORPORATION



CHAIN COMPANY

4567 S. Western Blvd., Chicago 9, III.

POWER TRANSMISSION DRIVES



*Stearnetic — Stearns exclusive unitized, electro-magnetic operating mechanism.



... up to 33% shorter

permits more compact, space-saving installations—less overhang... as much as 3 in. shorter than competitive units—up to $4\frac{1}{2}$ in. shorter than previous high-torque Stearns brakes.

... up to 50% lighter

easier to handle and install — cost less to ship... up to 50% lighter than competitive units.

- ★ Max. Torque Range 125 to 575 lb ft.
- ★ AC or DC models—all single phase
 only two lead wires for fast,
 simple installation.
- ★ Standard motor or floor mountings
 ... two styles of enclosures.

 ★ Evaluative Steams "Visi-Wear"
- ★ Exclusive Stearns "Visi-Wear" indicator.
- ★ Single point release single solenoid design.
- ★ For standard or straight-thru shafts.
- ★ Exclusive Stearns one-point adjustment for wear.
- * A screwdriver is your complete maintenance tool kit.
- * Wide-range torque variation for stops that match the application.
- ★ Smooth, clean, modern exterior design to match modern motors – no protruding parts to catch clothing — easy to clean.

Send for Special Information Sheet No. 2F

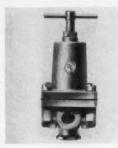


and storage temperature range is from -55 to +100 C. The units have a 100 mw dissipation rating at 25 C. Preliminary specifications have been established on five types for use in computer and other electronic circuit evaluations. Typical peak currents for these five units are: T101, 0.8 ma; T102, 1.5 ma; T103, 3.5 ma; T104, 7.0 ma; and T105, 15.0 ma. Sperry Semiconductor Div., Sperry Rand Corp., South Norwalk, Conn.

Circle 672 on Page 19

Pressure Regulators

can be used as two, three, or four-way units



Two low-cost pressure regulators are compact in design and feature excellent flow capacity and accuracy. Model 6 is for use with LP gas and No. 7 for acetylene gas. Constructed of die-cast zinc with internal parts of brass and diaphragm and disc of oil-resistant Buna-N, both are available in ½-in. size only. They can be used as two, three, or four-way regulators. Industrial Div., Watts Regulator Co., Embankment Road, Lawrence, Mass.

Circle 673 on Page 19

Duct Fittings

improved for lay-in wireways

Redesigned fittings for flangeless screw-cover and hinged-cover lines include new T-fittings, 90-deg elbow, and pull boxes, as well as cross-pull boxes. New angular side design gives more interior room in the units, and conductors bend more easily at corners, for safer, faster installation. To further increase the flexibility of wiring installation equipment, new 45, 22½, 7½ deg elbows, U-connectors, panel adapters for connecting wireways, panel

"...NEW MANUAL EXPANDS INFORMATION ON MINIATURE & INSTRUMENT BALL BEARINGS..."

By GEORGE HAMPSON, Vice President-Sales, New Hampshire Ball Bearings, Inc.

"... this 'Design & Purchasing Manual' replaces the first-of-its-kind 'Technical Data and Catalog' book NEW HAMPSHIRE published in 1957. As the 'Technical Data' (black cover) was then, we believe the 'Manual' (green cover) is now, the most complete source of information on miniature and instrument ball bearings in print. About 50 pages larger than the old book, the 'Manual' was expanded that much to include information developed since 1957 on ordering, maintaining, fitting, lubricating and testing miniature bearings."

QUALITY - AND ASSURANCE

"The significance of ABEC Class 7 tolerances to running quality of instrument bearings is covered in one section with a brief, to-the-point explanation of how improved bearing geometry helps the design and quality control engineer. A pictures-and-words story describes NEW HAMPSHIRE's Quality Assurance by which this high standard for miniature bearings is maintained in production. The equipment used, and how used, is fully described. Testing geometry and finish, cleaning and lubricating, functional testing of bearings, and metal research are some of the subjects covered."



EASY-TO-READ TABULATIONS

"An even easier-to-read tabulation form is used to list NEW HAMPSHIRE Bearings in Bore/OD/Width sequence for quick identification and selection when ordering or writing specifications. Three hundred seventy bearings are so listed, including NEW HAMPSHIRE wafers, the narrowest shielded retainer bearings possible for given Bore/OD combinations, and developed especially for manufacturers of synchros, servos, small motors, potentiometers, miniature gear trains, and other products where space-for-bearings is a problem."



BEARING NUMBERS EXPLAINED

"The 'Design & Purchasing Manual' includes a section on Designation, Packaging and Marking in which NEW HAMPSHIRE Bearing number symbols are explained, methods of packaging available from NEW HAMPSHIRE are described, and materials identification codes listed. Study of this section can work savings of money and time by minimizing the necessity of returning mistake-ordered bearings. In addition, simple HOW TO ORDER instructions are included on every page of bearing tabulations.

A Table of Weights is provided to assist those responsible for systems design and planning to compute weights of the NEW HAMPSHIRE Bearings specified and included."

ENGINEERING BULLETINS EXPANDED

"The Engineering Bulletins have been expanded and brought up-to-date to inform designers, engineers and quality control personnel of the latest developments related to Lubrication, Load Ratings, Fits, Speed, and other factors affecting performance and life of instrument bearings. There are now 22 Bulletins on as many subjects, including the two most recently developed, Duplex Bearings, and Bearing Roundness—one hundred seventeen pages of technical information on miniature and instrument ball bearings compiled and written by Bearing Engineers."

REGISTERED COPIES AVAILABLE

"The 'Design & Purchasing Manual' should be in the library of every designer, draftsman and buyer specifying or pur-

chasing miniature and instrument ball bearings. Each copy is registered to its recipient. Your name and title sent to us on your company letterhead will bring your copy to you by return mail."



HAMPSHIRE

BALL BEARINGS, INC.



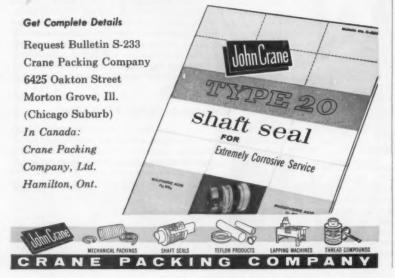
A new shaft seal to handle the most corrosive service conditions has been recently added to the John Crane line. Here's a seal that will stand up under all conditions of acids and salts, oxidizing agents and organic compounds.

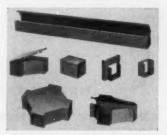
It is so designed that all parts that normally contact the fluid are made of chemically-inert DuPont Teflon. Also, for this same reason it can be operated over wide temperature range up to 250° F.

Mechanically, its bellows type construction readily adapts it for use in all non-abrasive slurry applications. It also compensates for extreme shaft run out.

Available in single face construction for internal or external mounting, double face for internal mounting.

Full range of shaft sizes from %" to 3".





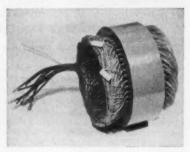
boards and switch gear, as well as lay-in adapters for changing the position of wireway runs, have been developed. Reducing bushings are also featured to permit mid-run reductions in wireway sizes. Standard wireways and fittings are made of heavy-gauge steel, with a corrosionresistant baked on gray enamel finish. Units are available in standard stock sizes of 21/2 x 21/2, 4 x 4, 4 x 6, 6 x 6 and 8 x 8 in. with lengths from 1 to 5 ft. They are also available with or without easy-out combination knockouts. Keystone Mfg. Co., 23328 Sherwood Road, Warren, Mich.

Circle 674 on Page 19

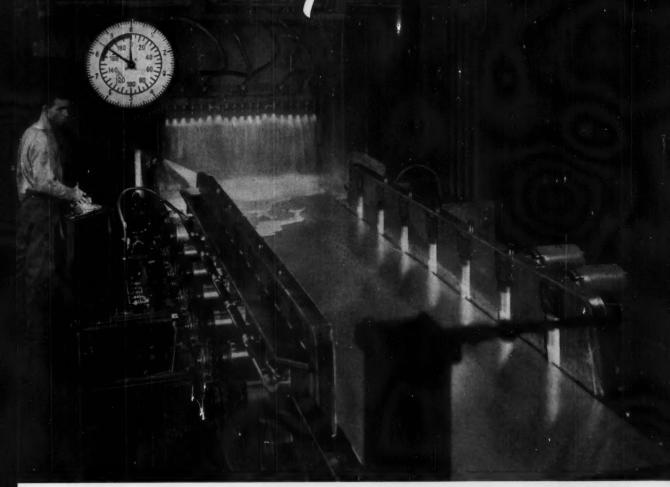
Induction Motor

features overload protection

Simple, positive, and fast-acting overload protection is available on all Tri-Clad '55 three-phase induction motors up to 125 hp, frame sizes 254U to 445U, in any insulation class or enclosure. The protection, Thermo-Tector, is provided by two or more miniature heat-sensing switches buried in the stator windings. The switches, connected in series with conventional motor control, shut the motor off whenever internal winding temperature exceeds a predetermined amount regardless of rate of temperature rise. Under rapid rise the Thermo-Tector switches anticipate and open the circuit at a lower temperature than when the rate of rise is slow.



MODERN EQUIPMENT PRODUCES LUCILITY ALL MINUM



Skilled QSM metal specialists, working with the best equipment in the business, produce aluminum sheet and coil of the finest quality!

Employing "unique" techniques on this 56"-wide hot mill, operators who have the "feel" for metal turn out quality aluminum that will meet the most exacting specifications.

With all our aluminum producing equipment, from cast house to finishing lines, located at our modern plant, QSM offers you faster service, more individualized attention and the best in aluminum sheet and coil. Want proof? Ask anyone on our growing list of satisfied customers.



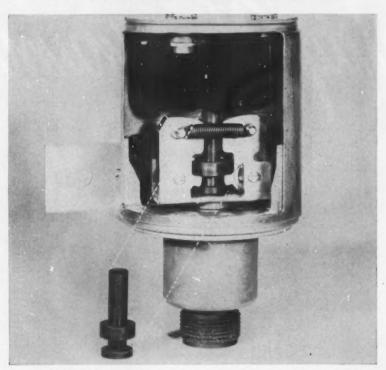


QUAKER STATE METALS CO. . LANCASTER, PA.

A Division of HOWE SOUND COMPANY

Mill Producers of Aluminum Sheet and Coil

Nylatron® GS gives life to critical control unit



NYLATRON GS nylon was specified for the actuating plunger on this overspeed governor after regular nylon, cold rolled and stainless steel failed to hold up. At 5000 R.P.M. speeds, nylon 66 failed due to excessive-thermal growth. Steel, in metal-to-metal contact, caused fretting corrosion. Economical NYLATRON GS, machined from bar stock, solved both problems.

Photo: Courtesy Synchro-Start Products, Inc.

NYLATRON GS (a compound of nylon and molybdenum disulphide*) offers both manufacturers and users many advantages over regular nylon and metals in applications such as this. In addition to its self-lubrication characteristics, NYLATRON GS has better-than-nylon wear resistance, higher strength, greater rigidity, superior heat resistance and improved dimensional stability. Yet it costs no more than standard nylon.



NYLATRON GS stock shapes are available in a complete range of rod, strip, tubing and plate forms for applications such as this. Rapid, low-cost fabrication is obtained on standard metalworking equipment. Molding powders are also available.

Complete stocks and technical services are as close as your telephone.

*Patented

Write today for full information

The Polymer Corporation of Penna.

Reading, Pa.



NEW PARTS AND MATERIALS

The Thermo-Tector system uses only two additional wires. Switches are small enough to be buried in the stator windings where the motor heat is generated, but they are rugged enough to handle size 4 contactor coil current. The new motors are particularly useful for unattended and outdoor applications and on continuous process lines where a motor burnout can cause costly downtime. General Electric Co., Schenectady 5, N. Y.

Circle 675 on Page 19

Nylon Ratchet Buckle

for perforated strapping

Nylon ratchet buckle makes perforated nylon strapping adaptable for many applications. Buckle holds one end of the strapping fast on its ratchet button. The other end adjusts to the desired tightness and cannot slip or loosen. Special clamps or hangars can be made



quickly and easily to any size for securing large bundles of wires, cables, rods, tubing, pipe, or any combination. Buckle is one-piece molded natural-color nylon, available in three sizes for use with 3/8, 1/2, or 5/8-in. wide strapping. Weckesser Co., Dept. MD-1, 5701 Northwest Highway, Chicago 46, Ill.

Circle 676 on Page 19

Air Cylinder

is single-acting, stainless-steel unit

Improved stainless-steel, single-acting air cylinder is now available with rolled-in construction on the rear as well as the front head. Wall thickness of the stainless-steel body has been increased by 50 per cent. The 1-1/16-in. bore, spring-return cylinder is available in stroke lengths through 3 in. A 5/8-18 hex nut is provided for front nose mounting.



Mirror-finish, stainless-steel body, and U piston cup mounted in an aluminum-alloy piston provide long life. Bimba Mfg. Co., 107 Main St., Monee, Ill.

Circle 677 on Page 19

Centrifugal Pumps

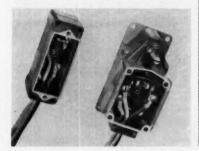
corrosion-resistant units in two new sizes

Centrifugal pumps in 8 and 3/8 in. sizes are extensions of present CNG pump line. In the 3/8-in. framemounted or monobloc design, the liquid end is constructed of a corrosion-resistant metal, and is available with either a standard packed box or internal mechanical seal. The 8-in. pump is a twin-volute type. Its liquid end consists of suction cover, volute, and stuffing-box head. The stuffing-box head has an integral water jacket which will either heat or cool the stuffing-box area. Worthington Corp., Harrison, N. J. Circle 678 on Page 19

Potted Limit Switches

exclude all liquids and foreign materials

For applications where large quantities of oil and coolant are present, line of potted limit switches is now available. Switches are prewired, and conduit entrances are sealed with epoxy resin. Units exclude all foreign materials and liquids. All Type-AW (small precision) and Type-T (heavy-duty) limit switches



NEEDED: EFFECTIVE VIBRATION ISOLATION AT TEMPERATURE EXTREMES



Vibration-sensitive equipment in high performance missiles and aircraft often poses a two-pronged problem to design engineers: effective isolation against destructive shock and vibration—at temperature extremes.

ANSWER: MB'S NEW BROAD' TEMPERATURE METAL ISO-DAMP MOUNT



MB's new broad temperature Iso-Damp mount consists of two load carrying springs, mounted in opposed position, with built-in damper assembly to restrict resonant build-up. It requires no external cooling, can be used at temperatures from -100° F. to $+500^{\circ}$ F.

WHAT'S <u>YOUR</u> MOUNT PROBLEM?

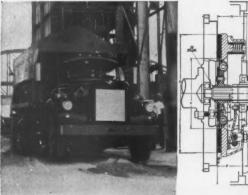


These new mounts can be adapted easily to the isolation of other special equipment as well. Or, perhaps one of MB's many other mount designs may be the answer to your particular vibration control problem. MB has not only the mounts, but also the experience and personnel to find the right answer for you. Write us for complete information—ask for Bulletin 418-4.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC. 1056 State Street, New Haven 11, Conn.

BOOKBORD



MORE PERFORMANCE MORE QUALITY MORE WORK LIFE In this NEW 'RT' CLUTCH



Make more new customers—more profit—by featuring this NEW "RT" ROCKFORD CLUTCH. More performance—it is increased by smooth engagement of precision parts, no binding, grabbing or friction. More quality—it is increased by the patented features of the rolling fulcrum pin, and the precisely balanced throw-out levers. More work life—it is increased by the reduction of friction heat, precision workmanship and the application of advanced research on the clutch facings.

These improved features make the NEW ROCKFORD "RT" CLUTCH a valuable asset to the prime movers of yesterday, today and tomorrow. The NEW "RT" clutch is now being used in high horsepower commercial vehicles and tractors, where rugged stamina is needed. For more new customers and more profits, specify the NEW ROCKFORD "RT" CLUTCH.

ROCKFORD L

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

== 311 Catherine St., Rockford, III., U.S.A. ==

Export Sales Berg-Warner International - 36 So. Wabash, Chicago S, III.

000000



Small Spring Loaded



Automotive Spring Loaded



Heavy Duty Spring Loaded



Oil or Dry Multiple Disc



Heavy Duty



Over Cente



Take-Offs



Speed



NEW PARTS AND MATERIALS

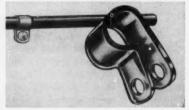
can be furnished in the potted design. Four No. 14 wires 5-ft long are furnished as standard. Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.

Circle 679 on Page 19

Plastic Cable Clamp

has molded contour for greater strength

One-nail or screw, plastic loop-type cable clamp now has a molded rather than heat-formed contour, providing greater strength at critical angles and a plastic memory in the



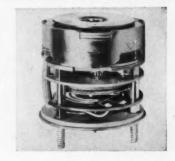
shape-of-use position. Clamp is deformed only to insert cable, harnesses, or tubing. Commercial Plastics Co., 941 George St., Chicago 14, Ill.

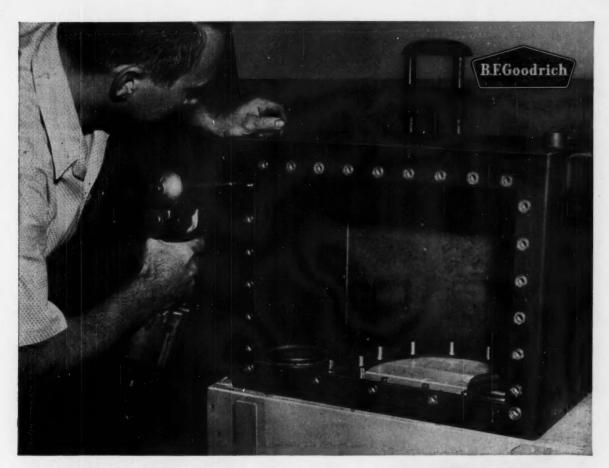
Circle 680 on Page 19

Compact Stepping Devices

for high-speed sequencing pulse control, switching

Series 18400 stepping devices are compact, have low power consumption and high reliability. For high-speed sequencing, pulse control and switching functions, the new units include: 1. Rotary stepping switches. 2. Pulse dividers. 3. Precision sequencers which can replace conventional solenoid or relay-actuated units. Stepping action is achieved magnetically, without ratchets, linkages or contacts. 1. Printed-circuit rotary stepper switches contain up





RIVNUTS® streamline tank design; eliminate damage to product

This oil reservoir, fabricated by Stolper Steel Corporation, Menomonee Falls, Wisconsin, for a husky new Allis-Chalmers tractor-shovel, requires removable cover plates. This is accomplished with flush-mounted RIVNUTS and threaded bolts.

With RIVNUTS, all possible damage is eliminated, since the RIVNUTS project inside the tank. Installation is simple: holes drilled and countersunk, RIVNUTS upset with a heading tool. Flush installation permits obtaining a liquid-tight joint without grinding.

RIVNUTS are the only one-piece blind rivets with internal threads. If you'd like recommendations on a specific fastening problem, please send a print of your part. For descriptive bulletin, see Sweet's Product Design File, or write Dept. MD-4, B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Akron, Ohio.



B.F.Goodrich Rivnuts



with easy-to-use EAGLE CYCL-FLEX reset timers

A highly accurate and dependable easy-to-use timer, designed for mounting in control panels. Sealed dial protects timer when exposed to oil and dust conditions. Timer switches control four load circuits. Interlocking contacts are provided without the use of auxiliary relays. Synchronous motor drive insures accurate timing.

WRITE for descriptive Bulletin 120. Address Dept. MD-460.

EAGLE HAS 24 TYPES TIME-COUNT CONTROLS



trial Timers and Counters



Cam Timer



Multi-Circuit Timers



Step Switc

EAGLE



SIGNAL COMPANY

MOLINE, ILLINOIS

REPRESENTATIVES IN PRINCIPAL CITIES

Circle 532 on Page 19

to 30 positions on a single deck. Each pulse cycle advances these switches one position to produce up to 2400 steps per minute at 24 v dc. "Home to reference" is possible by self-stepping or with 60-cps external power supply. 2. Precision-gated stepping switches can serve as pulse dividers for variable pulse sources, or as frequency dividers when the pulse source is constant. Output pulses can be factory-set in any desired proportion to input, i.e., I pulse out for 100 pulses fed in. 3. Precision sequencers perform single or multiple switch closures with accuracy equal to the pulse source itself. Applications include pulsememory storage systems. All units are custom designed, and conform to MIL-E-5272C. A. W. Haydon Co., 232 North Elm St., Waterbury,

Circle 681 on Page 19

Silicon Power Rectifier

is double diffused for standard and reverse polarity



Style 21, double-diffused silicon power rectifier is rated 13 amp average at 25 C ambient on a 3 x 3 x 1/16-in. copper heat sink. Standard and reverse polarity are achieved through the double diffusion. Typical forward dynamic resistance is 0.009 ohms. Syntron Co., 260 Lexington Ave., Homer City, Penna.

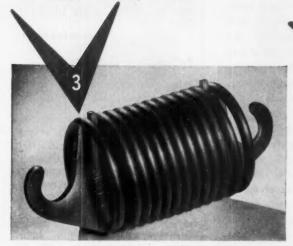
Circle 682 on Page 19

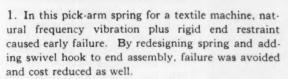
Hydraulic Safety Lock

prevents cylinder failure by stopping fluid flow

Safety lock for high-pressure systems operates as a pilot check valve, preventing hydraulic cylinder failure due to a line break or hose Why it pays
to look at the end
in the

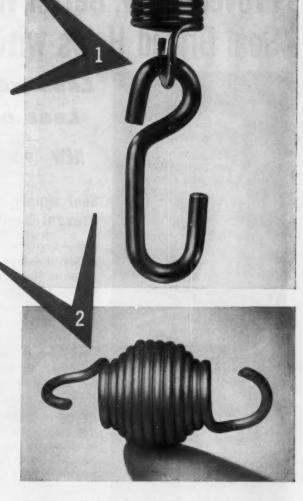
beginning





2. Fatigue failure caused by bending stresses occurs where end hooks join working coils. In this method of reducing the combined stress, two coils at each end are wound with a reduced diameter.

3. Another method for reducing stress concentration where end hooks join coils is to thread a flat stamping into end coils.



Here are a few examples of why it pays to call on the springmaker early in your design problems. End-hook failure of extension springs is a common occurrence that experience can help avoid. Check your specifications for performance and production economy by consulting an A.S.C. spring engineer. Write for bulletin "How to Solve Your Spring Design Problems."



General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y. B-G-R Division, Plymouth and Ann Arbor, Mich. Gibson Division, Chicago 14, III. Milwaukee Division. Milwaukee. Wis. Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.

Seaboard Pacific Division, Gardena, Calif. Cleveland Sales Office, Cleveland, Ohio Dunbar Brothers Division, Bristol, Conn. Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rica. Inc., Carolina, P.R.

5903

Seal Drilled Holes with

PLUG

ROOVE

Inserts

by

hand

REAMED

DRILL HOLE

In

your

castings



Seal simply, positively Prevent costly leaks!

Now - forget conventional, costly methods of sealing holes that serve as flow or pressure passages. The Lee "Pin Plug" is a cylindrical plug with a tapered reamed hole partway through its center and numerous small grooves on its outside surface. Simply place it into reamed hole and drive in the tapered pin until ends are flush. Controlled expansion causes grooves in plug to "bite" into casting and form independent seals and retaining rings. Extensive laboratory tests report no leaks under normal pressures, often show bone dry seals up to pressures of 40,000 psi.

Now successfully and widely used on aircraft and missiles - for pumps, servo valves, regulators, etc. Available steel and aluminum and in both long and short series.

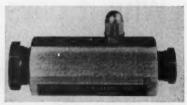
Pat #2,821,323



SOME TERRITORIES STILL OPEN FOR QUALIFIED TECHNICAL SALES REPRESENTATIVES.

> Write today for Standard Sizes and Engineering Data

THE LEE COMPANY OLD SAYBROOK, CONN.



The safety lock, installed at the cylinder inlet, allows con-tinuous fluid passage. In the event of a line break, the safety lock closes, trapping fluid in the hydraulic cylinder and preventing the supported load from dropping. The load can be lowered safely by turning set screw which gradually relieves the pressure. Ground Systems Inc., 9752 Cortada, El Monte,

Circle 683 on Page 19

Teflon-Glass Laminate

is highly resistant to chemical attack

No. 6098 Lamicord is a combination of Teflon resin and a fineweave, 0.002-in. glass fabric. It is highly resistant to chemical attack, has excellent electrical properties, outstanding resistance to mechanical abuse, and low cold flow under heat and pressure. One or both sides of the laminate can be bonded with 1 or 2-oz copper foil. Material is available in standard 17 x 37in, sheets in thicknesses from 0.006 to 0.250 in. Laminate meets the requirements of Military specification MIL-P-19161A. Mica Insulation Div., Minnesota Mining & Mfg. Co., Schenectady 1, N. Y.

Circle 684 on Page 19

Sponge Rubber

resists fuels and lubricants at high temperatures

A new Cohrlastic 10530 fluorosilicone sponge rubber compound has dense, uniform, nonabsorbing, closed-cell structure. It provides outstanding resistance to fuels and lubricants at high temperatures, and possesses immunity to aging, ozone, and weather hardening, excellent dielectric properties, and good compression set resistance. Sponge has little change in physical properties over a temperature range of -100 to +500 F. It is suitable for soft

gasketing, vibration dampening, fairing strips, pads, cushions, and other applications where there are extreme low or high temperatures with simultaneous exposure to fuels and oils. Molded sheets are 12 x 12 and 24 x 24 in., in ½, 3/16, and ½in. thickness. Connecticut Hard Rubber Co., 407 East St., New Haven, Conn.

Circle 685 on Page 19

Double Pumps

for speeds to 2000 rpm and pressures to 2000 psi

High-performance double pumps extend the range of applications for material handling, mobile, and off-



the-road construction equipment by providing a single power source that will supply two separate hydraulic circuits. Combined delivery can be used for greater volume. Design features permit normal operation at 2000 rpm and 2000 psi. Double-pump models are available with deliveries from 8 to 77 gpm. Most models have integral flow control and relief valve. Quick-change pumping cartridge, convenient fourposition inlet, and four-bolt SAE flange connections are other features. Vickers Inc., Div., Sperry Rand Corp., Detroit 32, Mich.

Circle 686 on Page 19

Motors and Generators

are available in new frame sizes

Extension in frame sizes provides a complete line of Kinamatic industrial motors, generators, and motorgenerator sets. Extension includes four NEMA frame sizes — 584A, 585A, 683A, and 684A—and results in 28 new dripproof motor ratings and 14 dripproof generator ratings. Design improvements include integral cast, main-field coil-and-pole(Please turn to Page 222)

IT'S WHAT HAPPENS ON

your job

THAT COUNTS! BHEW 'onthe-job' performance saves you money! Costly breakdowns and expensive maintenance do not make for efficiency. With BHEW products you are assured of dependable performance, long life and easy maintenance. These are the custom features that characterize all BHEW products.

RHFW

Cylinders are two-piece tubular rods that allow oil to flow through the rod in two separate channels to operate double-acting cylinders. You benefit from this application because the cylinder barrel is plain without port connections and the rod is anchored in a stationary position. The barrel is the reciprocat-

DISCUSS YOUR DESIGN AND APPLICATION PROBLEMS WITH USI



WRITE TODAY for free Hydraulic Cylinder Engineering Reference data. 78 dimensional basic designs for general purpose and special double- and single-acting cylinders, SAVE-TIME!



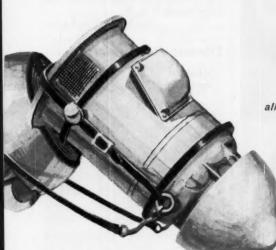
INTEGRITY · CHARACTER · QUALITY

BENTON HARBOR ENGINEERING WORKS, INC.

622 Langley Avenue • St. Joseph, Michigan



A.O. Smith has the horses!



800 to 1 hp favorites for quiet operation, low maintenance and long-life service...

all from the case of the A. O. Smith Motor Man

The horses of A. O. Smith make up the dandiest remuda an integral motor user ever saw. A complete line of longlived "easy keepers" — that includes . . .

SINGLE-PHASE DRIPPROOF INTEGRALS

(1-5 hp). Tough rolled-steel frames have mountings harnessed to either old or new NEMA standards. Exclusive sealed starting switch keeps 'em running free and easy.

POLYPHASE DRIPPROOF INTEGRALS

(1-800 hp). These front-runners are sound of wind, thanks to extra-value ventilation and insulation... sound of limb, thanks to extra care in electrical and mechanical design.

And A. O. Smith delivers the horses! Our motor man near you is on his mark with 24-hour action on all parts and service orders. He'll also show you a complete line of fractional-hp motors.

COPYRIGHT 1960, A. O. SMITH CORP.



Tipp City, Ohio

A. O. SMITH INTERNATIONAL S. A. Milwaukee 1, Wisconsin, U. S. A.

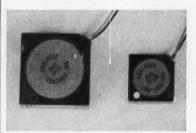
(Continued from Page 219)

assembly which can be replaced as a single unit. Class B insulation system is standard. Large or extra-large conduit boxes are available for mounting on either side of 580-680 frame Kinamatic motor. Internal wiring is arranged so that leads can be brought out from either side. Boxes can be rotated to bring out conduit in various positions. General Electric Co., Schenectady 5, N. Y.

Circle 687 on Page 19

Trimming Potentiometers

all-metal units operate to 150 C



Square trimming potentiometers have over-all dimensions of $\frac{3}{4}$ x $\frac{3}{4}$ x $\frac{9}{32}$ in. and $\frac{1}{2}$ x $\frac{1}{2}$ x $\frac{3}{16}$ in. The rugged, all-metal units operate to 150 C, meet or exceed MIL-E5272B and NAS 710, and are available in all resistance ranges. Spring-loaded worm gear assures reliable zero-backlash positioning with wiper position completely insensitive to shock and vibration. Analogue Controls Inc., Roselle Street, Mineola, L. I., N. Y.

Circle 688 on Page 19

Centrifugal Pump

has capacities to 16 gpm with heads to 28 ft

Suited for chemical circulating and transfer work in pilot plants and laboratories, or on equipment that requires the circulation of small quantities of clear corrosive liquids, $\frac{3}{4}$ in. centrifugal pump is now available in Hastelloy C Alloy as well as 316 stainless steel. Three principal parts of the pump—the casing, impeller, and adapter—are furnished in these materials, and all other parts are AISI 304 stainless steel. Hypalon O-ring provides an effective seal against leakage between



It's a long way from the drawing board to machines installed and operating in your customer's plant.

That's why the Bijur phantom is important to you now.

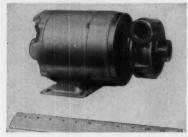
Your customers want increased productive capacity, reduced downtime, and longer machine life. Bijur Automatic Metered Lubrication, plus your own skill, can assure these customer benefits.

More than a million Bijur-protected machines are in use. Hundreds of leading manufacturers standardize on Bijur as "built-in" components of their machines. Bijur emphasizes custom-engineering, and we will gladly cooperate in designing a system to meet your specific requirements.

Write today for information that can lead to more profits for your customers.



Pioneers in Automatic Lubrication

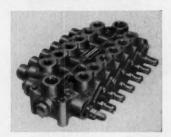


casing and adaptor without use of gaskets. Carbon, Teflon, and ceramic elements in mechanical seal provide excellent corrosion resistance. Capacities range to 16 rpm with heads to 28 ft. Standard dripproof or explosion-proof motors are available. Goulds Pumps Inc., 204 Black Brook Rd., Seneca Falls, N. Y.

Hydraulic Control Valve

for heavy-duty mobile equipment

Hydreco V-33 series valve is available in two, three, four, and sixplunger models, recommended for 20 gpm at 2000 psi. It has a parallel internal circuit designed for heavyduty mobile equipment where rapid sequence of multiple functions is required. Valve can be furnished with built-in, pilot-operated overload relief valves on individual cyl-



inder circuits. They prevent damage from high static pressure that may be developed in a blocked cylinder circuit, Hydreco Div., New York Air Brake Co., 9000 E. Michigan, Kalamazoo, Mich.

Circle 690 on Page 19

Pressure Switch

miniature unit has operating range of 0-500 psi

Model PS375-1 pressure switch provides positive, snap-action switching in response to changing pressures in



STAINLESS STEEL
the
PRACTICAL **
WAY
with

Mechanical Properties

Can be sheared, machined, ground, bent to 180° without damage, Stretched or deep drawn to fracture point of metal.

Physical Properties

Withstands extremes of heat, cold, water, humidity, abrasion, chemicals (even 30% solution of sulphuric and hydrochloric acids), solution, but you are and chemical control of sulphuricant and chemical control of the sulphuricant and chemicant and chemicant and chemicant and chemicant and chemicant and chemicant and chemica

Weatherability

Fade-resistant. Will not chip, peel or corrode



ARDMORE TEXTURED METALS

For the first time! A practical combination of the amazing properties of stainless steel and beautiful, durable color...made possible through exciting new Ardmore Textured ColorRold.

With highlighted Textured ColorRold the brilliantly burnished facets of stainless emerge from a background of harmonious hues. These polished tops of the texture elements not only bear the brunt of wear and abuse, but add a dramatic accent to your designs. Subtle effects can be achieved by leaving the texture elements unpolished.

The precision flow-coated ColorRold film is not an ordinary baked-on paint—it is a "cured" acrylic resin specifically formulated to weld to the surface of stainless steel. It is endowed with many previously unattainable properties described briefly above, and is available in a wide array of colors and finishes calculated to please every taste.

Ardmore Textured ColorRold with all its unique advantages for designs ranging from curtainwall building panels to appliances and cars, surprisingly, can cost less than color anodized or porcelain enameled metals. Be the first to capture the imagination (and the "pocket-

books'') of your market with Ardmore Textured ColorRold.



upper left
Oxford Texture highlight

lower right Leeds Texture soli

Standard colors by Howard Ketcham: Metailics: Gold, Bronzo, Gunmetal Noa-Metailics: Rad, Blue, Yellow, Gray, Green, White, Turquoise, Bleck.



Send today for new 4-page brochure which describes all textures and finishes available (including ColorRold) with photos of applications in all industries. See ads in Thomas' Register and Sweet's Product Design File If

ARDM

PRODUCTS,



1914 ALDENE ROAD • ROSELLE, NEW JERSEY
Telephone: In New Jersey — CHestnut 5-5400 • In New York — Digby 9-0838

Sales Representatives in Principal Cities



THE MAN & THE MOTORS





Mr. Westinghouse*brings Kling Bros. Engineering modified <u>fife-line</u> motor to replace expensive shop-built drive

To meet the demanding requirements of a motor for their high inertia friction saws, Kling Brothers Engineering Works had been forced to fabricate their own motor frames, brackets and shafts. Balancing was also done in their shop to meet the exacting mechanical tolerances.

The Kling saw uses the motor shaft as the spindle head with the motor mounted on a special base located on their machine. Mounting tolerances must be held to 0.001".

When Kling called in Mr. Westinghouse, he suggested some modifications to the standard Life-Line® "A" motor to meet all their requirements. One compact unit now serves their needs . . . at much less cost than their handmade drives.

The Westinghouse Life-Line "A" motors feature a pull-out torque of 350 to 400%. To accommodate the high radial thrust, oversize bearings and shafts are used. Locked bearings limit any end play of shaft. A tapered shaft permits the saw blade to be mounted directly on the motor. A coordinated balancing program at Buffalo (with motor alone) and the Chicago area M & R shop (complete with blade) assures perfect performance of the finished machine.

Mr. Westinghouse can help you with your drive needs whether they are standard or special. You can depend upon him to give you peak performance just as he did at Kling.

*Ralph Recka, Westinghouse Sales Engineer in Chicago.

FROM WESTINGHOUSE



Mr. Westinghouse* and the **Life-Line** motor brought 56,940 hours' continuous service in highly corrosive atmosphere to Allied Chemical's General Chemical Division

When General Chemical called in their Westinghouse sales engineer back in 1953, they had a serious drive problem. An electric motor was required for 24-hour service in an atmosphere containing hydrogen chloride, sulphur dioxide and sulphur trioxide. Ambient conditions varied from 70° to 100°F.

A Westinghouse Life-Line "A" Type TEFC motor was selected to power a screw conveyer that feeds raw material at the rate of seven tons every 24 hours, 365 days per year, from storage hoppers. A motor breakdown would result in a two-hour shutdown of the equipment it serves.

After more than 6½ years of 'round-the-clock operation, this Westinghouse Life-Line "A" motor is still giving trouble-free service under very severe operating conditions. Such a record indicates many more years of outstanding service.

Mr. Westinghouse is well equipped to step in and help you solve your drive problem . . . just as he did at General Chemical Corporation.

*Tom G. Broussard, Westinghouse Sales Engineer in Philadelphia.

J-22156

Call in The Man from Westinghouse when you need help on your electrical drive requirements. He's well equipped to supply motors from fractional hp to hundreds of "horses." And he'll show you how to save money . . . whether it's a shelf

item or a custom-engineered motor you need. For additional information write: Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

YOU CAN BE SURE ... IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV ALTERNATE FRIDAYS

Circle 540 on Page 19

To Get The Flexible Coupling Best Suited For Your Job ... use Flexible Coupling Guide

Save time, money and mistakes, insure trouble-free performance . . . by using the Lovejoy Flexible Coupling Guide. You'll get the exact type and size for your particular application -plus all these Lovejoy features:



Type L-070 is exactly fitted to the requirements of this gear pump.

- · No lubrication required.
- · Simple, rugged constructionfew parts, no intricate mechanisms.
- No wear on metal parts—the load is transmitted through cushions only.
- · Double-life cushions—one half the cushions act as idlers, except on reversing loads. Thus, a quick interchange provides a new set of cushions.
- · Cushions engineered to load and service conditions.
- A maintenance-free coupling that is completely machined for ease and speed of align-
- Act now! Send for your Flexible Coupling





maintenance and trouble-free performance in

trifugal pump is the spacer type RRL which permits quick, easy disassembly without disturbing piping. (Cour-

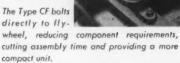
tesy Dean Brothers Pumps, Inc.)



Type C-152 gives

a portable power unit.

The Type CF bolts directly to fly-



air, fuels, lubricants, gases, or other media. Extremely small, it measures 1 in. long by 1 in. diameter, and has an operating range from 0-500 psi. Repeatable accuracy is within ±0.5 per cent of original setting, depending upon operating range. Switch is rated for 6 amp at 125/250 v ac. Capsular-type sensing element assures excellent sensitivity and repeatability, and low hysteresis and drift



over a temperature range from -65 to +300 F. Design uses only one moving part. Switch meets MIL-E-5272A and takes up to 100 g shock. Pamar Electronics Co., 103 Marine St., Farmingdale, N. Y.

Circle 691 on Page 19

Epoxy Plastic

flame-resistant resin for molding, encapsulating

Flame-resistant epoxy No. 1202 is for applications like computers, where flame-resistant properties are vital, and for encapsulating electronic components. Properties: Extinguishing time, 0 to 1 sec; thermal conductivity, 9.2 × 10-4 cal/sec/ cm²/deg C/cm; water absorption (24 hr), 0.04%; weight loss (24 hr at 150 C), 0.26; dielectric constant (1 meg), 5.6; dissipation factor (1 meg), 0.028, volume resistivity at 25 C, 1.3 × 1015, at 125 C, 4.7 \times 10¹² at 150 C, 3.1 \times 10¹⁰; insulation resistance (96 hr at 90% RH and 95 F), is 9×10^{10} . Molded epoxy electronic component packages have successfully been tested for 1000 hr at 200 C. Forms include molded cylindrical and square sheets, custom-molded components, and liquid. Epoxy Products, 137 Coit St., Irvington, N. J.

Circle 692 on Page 19

OY FLEXIBLE COUPLING

4818 WEST LAKE STREET

CHICAGO 44, ILLINOIS



Arwood adds a new dimension to investment casting—

SIZE

Until now, an investment casting has been something you could hold easily in one hand. Today, thanks to a series of technological breakthroughs, Arwood can offer you investment castings so large and heavy that you need two hands even to budge them from the floor!

The new weight limit approaches 100 pounds.

What does this mean to you? It opens a whole new realm of possibilities in the design of component parts. For the first time, a designer can avail himself of investment casting's special advantages over a complete size range that runs from a fraction of an ounce up to weights heretofore available only in sand castings. Advantages like investment casting's ability to reproduce complex, hard-to-machine shapes in any castable metal or alloy . . . its low initial tooling expense . . . the dimensional accuracy and smooth surface finish characteristic of investment cast parts.

So . . . for quality investment castings in any ferrous or non-ferrous alloy . . . and in any size and weight . . . check with Arwood. We can free your hands to design for function and end use, because we can give you the *shape* you need in the *metal* you need in the quantity you need, no matter how *large* the part on your board. All five Arwood plants stand ready to serve you.

Write for your free copy of our 44-page "Practical Guide to Investment Casting."

Visit us in Booths 117 and 119 at the Design Show

Machine the simple . . . cast the complex

A complete service from design through tooling, production and finish machining. Seventy - one engineering representatives from coast to coast.

arwood -

ARWOOD CORPORATION • 315 West 44th Street, New York 36, New York PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.

* ANOTHER FIRST FOR AICO *

AICO-molded laundry tub wins top consumer award at annual SPI exhibit

Coveted 1st Prize for Consumer Products was awarded this AICO-molded laundry tub at the 1960 conference of The Society of Plastic Industry's Reinforced Plastics Division. The award-winning appliance was molded of reinforced plastic by a new "Premix" process . . . a process planeared by AICO and one that offers outstanding benefits to manufacturers in many fields of industry.

costcutting
process
for
countless
applications



For the manufacturer, the low cost of the new Premix Process is only the first of many proven benefits. Aico Premix Molded Products have built-in consumer appeal . . . surfaces are glossier, smoother . . . attractive colors blend eye-appeal . . . general appearance and buy-appeal is greatly improved. Most important of all . . . the new AICO Premix Process opens up countless new applications for reinforced plastics . . . applications in every field of manufacture that were previously impossible because of the cost factor or physical limitations of existing methods.



FREE to help you make better use of plastics



AICO PLASTICS
DESIGNER'S HANDBOOK
Tells and illustrates
how low unit cost
can be achieved
through proper
plastics design.



AICO PLASTICS
APPLICATOR
Tells molding material best suited
for your product—
tells how it should
be molded.



AICO FACILITIES BOOKLET

Tells how to select a fully-equipped molder to do your job...shows how to avoid split responsibilities.

Write for your FREE copies today

DISCOVER HOW YOU CAN CUT PRODUCTION COSTS WITH AICO'S "PREMIX" MOLDED PLASTIC PARTS



AMERICAN INSULATOR CORPORATION

New Freedom • Pennsylvania

ENGINEERING DEPARTMENT

EQUIPMENT

Drawing Kits

are portable for easy carrying

Drawing kits in four sizes can be used for sketching and temporary layout work. Lightweight basswood drawing board has finished fixed head, maple T-square, and two transparent triangles with



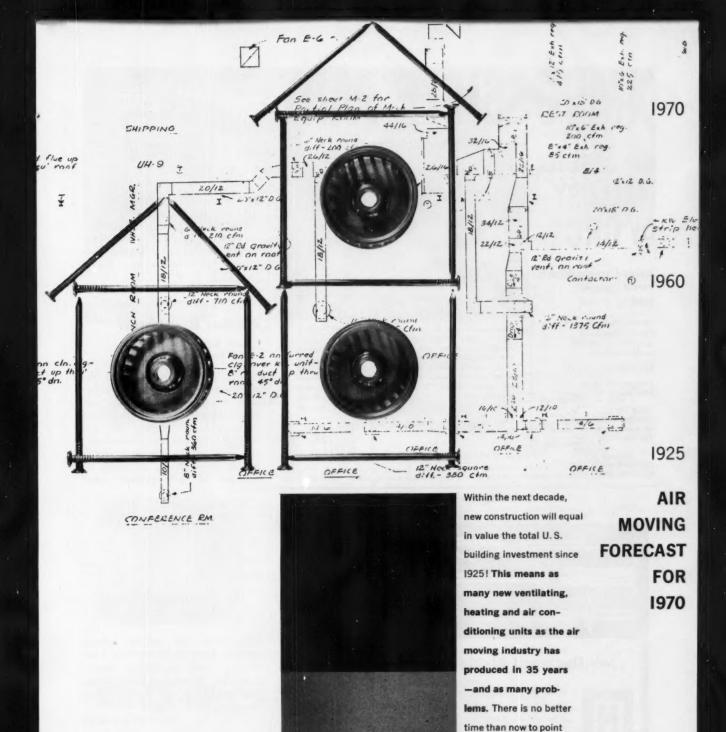
finger lifts, one 45/90 and the other 30/60 deg. Built-in T-square holder on back of board holds triangles in place when not in use. Sizes are 10 x 12, 13 x 19, 17 x 22, 19 x 25 in. Portable and compact for easy carrying, kits are supplied with waterproof plastic jackets. Alvin & Co. Inc., 611 Palisado Ave., Windsor, Conn.

Circle 693 on Page 19

Power Supplies

transistorized units are for laboratory applications

Trylab transistorized power supplies, designated specifically for laboratory applications, furnish 0-36 v dc at 0-600 ma and 0-18 v dc at 0-1 amp, with 0.05 per cent line and load regulation and less than 1 mv ripple. Automatic short-circuit protection is provided with variable current-limiting provisions to enable drawing only the required amount of power. Regulator network, featuring a by-pass resistor technique, allows power transistors to operate at a lower temperature by dissipating excess electrical energy in power resistors. Electrolytic capacitors allow operating ambient



THE TORRINGTON MANUFACTURING COMPANY

out that Torrington's capabilities in the technology of moving air—and in the production of air moving components—are rated as the finest in the world.

AIR MOVING DIVISIONS Torrington, Connecticut; Van Nuys, California; Rochester, Indiana; Oakville, Ontario

"IMPOSSIBLE" PART

die cast for MALLORY by GRC

helped create higher rated, longer lasting switch

Quick deliveries on quantities of 100,000 to many millions.

NO SIZE TOO SMALL!

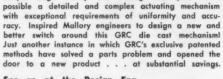
Max. weight ½ oz. Max. length 1¾"

Write for detailed bulletin or send prints



for quotation.

25 years of



"Impossible", yes, by any other method. BUT-GRC's

unique single cavity die casting techniques made

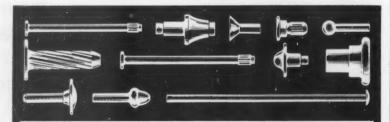
See us at the Design Eng. Show—BOOTH 2435



GRIES REPRODUCER CORP.
World's Foremost Producer of Small Die Castings
32 Second St., New Rochelle, New York, NEw Rochelle 3-8600

@ Z Q

Circle 545 on Page 19



Job-Designed Rivets for Every Industry



Here is a fast, dependable, low cost, quality minded source of supply for JOB-DESIGNED fasteners of all types, in any

metal, to fit your own assembly problem. Assembly costs are a very major part of manufacturing expense. Most of this is labor. The fastening medium itself is usually a minimum item. If a Job-Designed fastener makes assembly simpler and faster, permits the use of fewer fasteners, allows the designer functional freedom and improves product efficiency, yours is a specifying job well done. All these possibilities are available when you come to Hassall for design assistance and quotation on challenging, difficult or unusual rivets, threaded nails, drive screws and other cold headed parts. Short or long runs, pilot quantities, engineering counsel, over 100 years of intimate association with cold heading—and a deep appreciation for the concept of value analysis—all are part of the Hassall service to you.

Send for a copy of our latest catalog.

JOHN HASSALL, INC.

MANUFACTURERS SINCE 1850 P. O. Box 2197 • Westbury, Long Island, N.Y. ENGINEERING DEPT. EQUIPMENT



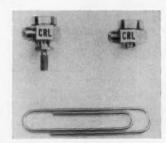
temperature to 50 C and storage temperature to 85 C. Trygon Electronics, 111 Pleasant Ave., Roosevelt, L. I., N. Y.

Circle 694 on Page 19

Miniature Accelerometers

have high sensitivity over broad ranges

Series 200 miniature crystal accelerometers are for use in applications where size and weight are critical factors. Units are less than ½ in. wide and slightly over 1/3 in. high. Instruments have detachable steel or phenolic studs which permit either direct mounting or isolation of accelerometer case.



Compression-type seismic system provides high sensitivity over wide frequency and acceleration ranges.

Columbia Research Laboratories, MacDade Blvd. and Bullens Lane, Woodlyn, Pa.

Circle 695 on Page 19

General-Purpose Oscilloscope

provides accurate, reliable visual-circuit analysis

Model ES-525 oscilloscope is an extremely stable, reliable general-purpose unit which incorporates latest circuitry and maximum of flexible functions required for general-purpose applications. Model shown is the complete instrument for accurate, reliable visual-circuit analysis. It is $8\frac{1}{4} \times 14\frac{1}{2} \times 18\frac{1}{2}$ in.



Weatherhead

offers one source for all tube fitting needs... a complete line of flared, flareless or pipe...

TUBE FITTINGS of BRASS, CARBON STAINLESS STEEL

FITTINGS BRASS

FORGED STEEL FITTINGS



S.A.E. 45° FLARE

S.A.E. 45° FLARE
USED with copper, brass, aluminum, steel and plastic tubing.
PRESSURE RATINGS up to 5000
p.s.i. Sizes: ½" A y available in 37° heavy pattern brass.
Listed by U.L.; approved by A.G.A.
Meets specs of S.A.E. Hydraulic
Tube Fittings Standards and A.S.A.
and A.S.M.E. codes for instruments
and control piping.



"7000" SERIES ERMETO®

"JOU" SERIES ERMETOW.

U.L. listed. Meets J.I.C. standards.

S.A.E. approved "0" Ring boss design. Dryseal pipe thread. Needs no flaring. Available in either carbon or stainless steel. Carbon steel fittings have "Weathercoat" or cadmium-plate finish. PRESSURE RATINGS: up to 10,000 p.s.i. Size Ranges—½" through 2".



COMPRESSION

USED with copper, brass, aluminum and plastic tubing. PRES-SURE RATINGS up to 2000 p.s.i. Sizes: ½" to ¾". Listed by U.L.; approved by A.G.A. Meets specs of S.A.E. Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping.



"8000" SERIES ERMETO®

"States between two countries of the cardous liquids, fuel equipment, refrigeration and gas; meets specs of
S.A.E. and J.I.C. hydraulic tube
fitting standards. Supplied as
standard in cadmium-plated carbon steel and in stainless steel.
Requires no flaring. PRESSURE
RATINGS: up to 10,000 p.s.l.
Size Range—1/4" through 2".



SELF-ALIGN®

No flaring, soldering, welding-insert tube and tighten nut. USED with copper, brass, aluminum and plastic tubing. PRESSURE RAT-INGS up to 2000 p.s.i. Sizes: ½" to ¾".



FLARE-TWIN-(2-pc, or 3-pc,)
37° FLARE STEEL TUBE FITTINGS
Listed by U.L. S.A.E. and J.I.C.
approved. Used with J.I.C. and
other soft steel tubing; also with
copper, aluminum, and fully unnealed stainless steel tubing.
Moets S.A.E. standards for straight
thread boss mounting. PRESSURE
RATINGS up to 10,000 p.s.I.
Sizes: ¼" through 2".



INVERTED FLARE

USED with copper, brass, aluminum, steel, Bundyweld and plastic tubing. PRESSURE RATINGS up to 3000 p.s.i. Sizes: ½" to 3½". Listed by U.L. Meets specs of S.A. Hydraulic Tube Fittings and A.S.A. and A.S.M.E. codes for instruments and control piping.



FLARE-TWIN

Made in 3-piece and 2-piece as-semblies. 2-piece type offers price advantage. "Weathercote" or cad-mium-plate finish.

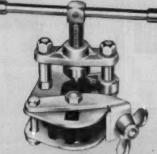


PIPE

USED with brass or steel pipe. PRESSURE RATING: up to 5000 p.s.i. Sizes: to 2". Meets specifica-tions of S.A.E. TPHL Fittings Com-



FAST! EASY! ACCURATE TUBE WORKING TOOLS





Mechanical







matic Flaring

WEATHERHEAD THE COMPANY

FORT WAYNE DIVISION . Dept. MD-4, 128 West Washington Blvd Fort Wayne, Indiana



FREE reprints from DESIGN



Limited supplies of the following reprints of articles which have appeared in MACHINE DESIGN are still available at no cost. Circle the ones you want on the order form below and mail to Reader Service, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

- Tables and equations simplify design of CONICAL-DISC SPRINGS by Earlwood T. Fortini, September 4, 1958 (8 pages)
- SYMBOLS FOR GEOMETRIC TOLERANCES by Fred L. Spalding, October 15, 1959 (8 pages)
- 3 A Guide to TECHNICAL ILLUSTRATION by Hans Peter Nelson, March 6, 1958 (8 pages)
- ANALOG COMPUTING MECHANISMS by George W. Michalec, March 19, 1959 (24 pages)
- 5 CHOOSING THE RIGHT COLOR by Faber Birren, August 6, 1959 (7 pages)
- 6 HEAT-TREATED POWDER-IRON PARTS for improved strength and hardness by Navin Kothari, October 30, 1958 (4 pages)
- Numerical rules for designing PLANETARY GEARS by Robert L. Benford, August 21, 1958 (7 pages)
- SIMPLIFIED COLUMN DESIGN by Helmut G. Hoeschel, 8 April 2, 1959 (6 pages)
- LINEAR ENERGY ABSORBERS by Lloyd M. Polentz, March 5, 1959 (6 pages)
- 10 CENTRIFUGAL CASTINGS, October 15, 1959 (6 pages)
- DESIGNING FOR BALANCE in rotating parts and assemblies 11 by Robert R. Zenk, May 28, 1959 (8 pages)
- Mechanics of applying ELECTRIC MOTORS by W. R. Harris, 12 November 28, 1957 (6 pages)
- Designing INTERFERENCE FITS by F. R. Archibald, October 13 30, 1958 (2 pages)

Send reprints without charge as circled below:

10 11 12 13

Penton Building Cleveland 13, O.

TITLE NAME

COMPANY

ADDRESS

ZONE CITY

ENGINEERING DEPT. EQUIPMENT



in size. Square-wave response ranges from 20 cps to 50 kc. Precision Apparatus Co., Inc., 7031 84th St., Glendale, L. I., N. Y.

Circle 696 on Page 19

Electric Duplicator

reproduces 120 copies per minute

Low-cost Model D-21 electric duplicating machine reproduces 120 clean-cut copies per minute of anything typed, written, drawn, or Machine delivers 300 to traced. 500 sharp copies in one to five colors from a single duplicating master on any weight paper from 16 lb to card stock. Paper size ranges from 3 x 5 in. Sure-Feed system features new feed-pressure lever, paper separators, side guides, and lift lever for fast paper insertion. Ditto Inc., 6800 N. Mc-Cormack Rd., Lincolnwood, Ill.

Circle 697 on Page 19

Transistorized Power Supply

has continuously variable output of 0-50 v dc

New transistorized power supply measures 5 x 5 x 6 in. Input voltage is 95 to 135 v ac, rms, 60 cycle, single phase. Output voltage range is 0-50 v dc, continuously variable, and output current is 0 to 1/2 amp dc. Regulation is 0.02 per cent no load to full load, adjustable from a 1-v increase to a 1-v decrease, no load to full load. After an initial stabilization period of 15 sec, output voltage does not change more than 0.07 v about desired setting. Ripple is 4 my rms. Autotronics Inc., Dept. 23, Box 208, Florissant,

Circle 698 on Page 19

THE ENGINEER'S

Library

Recent Books

Electronic Computers, Principles and Applications. By T. E. Ivall; 263 pages, 5¾ by 8¾ in., clothbound; published by Philosophical Library Inc., 15 East 40th St., New York 16, N. Y.; available from Machine Design, \$15.00 per copy postpaid.

This book presents a nonmathematical introduction to the principles and applications of computers employing vacuum tubes, transistors, and other electronic devices. Treatment is general and gives a broad background picture of the field of computing.

Circuitry and construction of digital and analog computers are covered, and their applications in industry, science, and commerce are outlined. Emphasis is placed on applications to automation or control techniques in industry, and also on those computing techniques that are playing an important part in research and design work.

Calculus Refresher for Technical Men. By A. Albert Klaf; 431 pages, 5½ by 8 in., paperbound; published by and available from Dover Publications Inc., 180 Varick St., New York 14, N. Y.; \$2.00 per copy.

The most important aspects of integral and differential calculus are examined in terms of 756 questions most likely to occur to the technical reader. Topics included are functions, increments, derivatives, partial differentiation and integration, and double and triple integration.

Acrylic Resins. By Milton B. Horn; 184 pages 5½ by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; \$4.50 per copy.

Four types of acrylics are described with respect to manufacture, fabrication, and application. Discussion includes cast products, molding compounds, emulsions, and solution compounds.

Background information about



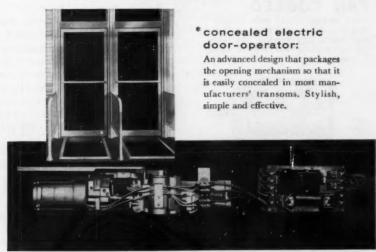
Norton sought to develop the lightest, smallest, most attractive door-operator available . . . one whose entire mechanism could fit a slender door header.

Key to design was a motor that could meet these specs: 1) shorter than 5"; 2) less than 4" in diameter; 3) totally enclosed, nonventilated; 4) high torques; 5) special shaft; 6) special end bell. The result is seen below.

Like Norton designers . . . and many others . . . design your product to do a job and to sell, not to fit a motor.

Whatever your motor need, you set the electrical, physical, mechanical and environmental conditions. We'll do the rest. Our range is 1/8 to 3 hp, up to 15 hp for submersible motors.

For further data, write to: Jack & Heintz, Inc., Commercial Motor Division, 17626 Broadway, Cleveland 1, Ohio.



AROUND 7
THE CLOCK PERFORMANCE

that's what you get when you Specify...

VALLEY BALL BEARING MOTORS

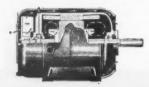
HERE'S WHY ...

First of all they are specifically engineered to meet the exacting requirements of most power needs — regardless of type or location. Then too, they insure constant, uninterrupted service in high temperatures because they are always cool running. Having enclosed ball bearings you are assured of complete protection against harmful dust and grit. Furthermore, they can handle most power load emergencies without damage to its operating parts.



FAN COOLED

Totally enclosed VALLEY Motor Polyphase, 50 to 60 cycles, constant speed, continuous duty, squirrel cage induction, high terque, low starting current and fully ball bearing, 2 to 60 h.p.



VALLEY
ELECTRIC CORPORATION
4221 FOREST PARK BLVD. ST. LOUIS B. MO.

Circle 550 on Page 19

raw materials and manufacture of these polymers is presented because it is essential to an understanding of the problems involved in fabrication and application. Current and future developments of acrylics in terms of potential use are covered.

New Standards

1959 Supplement to Book of ASTM Standards Including Tentatives, Parts 1, 2, 3, 7, and 9. Each book is 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; \$4.00 per copy.

Part 1—Ferrous Metals; 362 pages. Included are 58 standards on steel pipe, tubes, castings, bolting materials, boiler plates and rivets, sheet and strip, bars, forgings, and various other ferrous metal products.

Part 2—Nonferrous Metals and Electronic Materials; 280 pages. Included are 38 standards for copper and copper-base alloys, aluminum and aluminum alloys, magnesium and magnesium alloys, and related products. Also, tin, nickel alloys, titanium, materials for electrontube and semiconductor devices, and metal powder and electrodeposited metallic coatings are included.

Part 3—Methods of Testing Metals; 110 pages. Included are 14 standards for tests for mechanical properties, effect of temperature, corrosion, and electrical and magnetic properties. Nondestructive testing and sampling methods are also included.

Part 7—Petroleum Products, Lubricants, Tank Measurement, Engine Tests; 428 pages. Included are 43 standards for liquefied petroleum gases, motor and aviation fuels, solvents and naphthas, diesel fuels, engine lubricating oils, and related products. In addition, engine-test methods for rating fuels, tank measurements, and sampling standards are included.

Part 9—Plastics, Electrical Insulation, Rubber, Carbon Black; 546 pages. Included are 74 standards for plastics, molding compounds, and shapes; tests for mechanical, thermal, optical, and permanence properties of plastics, as well as effects of radiation. Also included



UNSURPASSED QUALITY AT REGULAR MILL PRICES

.010" O.D. to 1.125" O.D. Copper, Brass, Branze

• Why play checkers jumping from one supplier to another for better "buys" and better quality? You'll find your ultimate answer in the temper, straightness, roundness and size tolerances of Precision Tubing.

Precision Tubing is carefully tested and pre-tested in every step of production. Skilled craftsmen using modern drawing equipment and dies which are "quality-controlled" in our own shop assure Nth degree accuracy in every foot of tubing drawn. Electronically controlled annealing produces tubing to meet your most exacting specifications.

Precision also makes round, rectangular, Bourdon, oval or square, preformed to special shapes . . . in copper brass, aluminum, nickel and nickel-alloys, Ni-Span "C", phosphor-bronze and nickel silver.

Let our engineers help you improve quality and save money.

Write for full details to

PRECISION TUBE CO., INC.
North Wales, Pa.





Modern board-lift forging hammer

By designing front-end spindles to be forged, automobile and truck manufacturers practically eliminate danger of failure of these vital parts, even under sudden turning stress that can reach thousands of foot-pounds.

Start your designs by planning to use forgings everywhere there's a high degree of stress, vibration, shock, or wear. Forged parts withstand them all better than parts made by other fabrication methods. And forgings have no hidden voids to be uncovered after costly machining hours have been invested ... the hammer blows or high pressures of the forging process compact the better forging metal, make it even better.

Write for literature on the design, specification, and procurement of forgings.

SEE THE WHOLE STORY OF FORGINGS DESIGN ENGINEERING SHOW, NEW YORK, MAY 23-26.

When it's a vital part, design it to be FORCE



Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents—yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on Machine Design, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a designengineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.



are electrical insulating materials such as shellac, varnish, and ceramic products.

Association Publications

Proceedings-Sixth National Symposium on Reliability and Quality Control in Electronics. 578 pages, 8½ by 11 in., paperbound; available from Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.; \$5.00 per copy.

Mathematical, production, and maintainability techniques, military requirements and specifications, reliability prediction, failure modes, system aspects, life tests, cost considerations, and programs and management were general areas of discussion.

Some topics included in the 65 papers are reliability testing of military products, mathematics of reliability, circuit-design concepts for high reliability, designing in the dark, and design reviews.

Government Publications

NASA Technical Notes. Copies of publications listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TN D-160. Compressive and Tensile Creep of 7075-76 and 2024-T3 Aluminum-Alloy Sheet, By G, J. Heimerl and J. Farquhar, Langley Research Center; 40 pages, 7% by 10½ in., paperbound, side-stapled; \$1.00 per copy. Results

Results of compressive and tensile creep tests of 7075-T6 and 2024-T3 aluminum-alloy sheet at 300 F, 375 F, 455 F, and 600 F are presented. Various comparisons are made to show relationships between the two alloys in the primary and secondary creep regions.

TN D-210. Rotating-Beam Fatigue Tests Notched and Unnotched 7075-T6 Aluminum-Alloy Specimens under Stresses of Constant and Varying Amplitudes, By H. F. Hardrath, E. C. Utley, and D. B. Guthrie, all from Langley Research Center; 34 pages, 7% by 10% in., paperbound, side-stapled; \$1.00 per

copy.

Tensile and compressive tests were performed to obtain stress-strain curves for 80 tensile specimens and 80 compressive specimens. Ultispecimens and stressers and elongation in a 1-tensile stressers and elongation in a 1-tensile stressers. specimens and so compressive specimens. Utilinate tensile strength, and elongation in a 1-in, gage length were also measured on tensile specimens. Constant-amplitude fatigue tests were conducted on specimens having three different shapes. Fatigue tests with varying stress amplitudes were conducted only on unnotched and 0.010-in.-radius notched specimens.

mens.

TN D-270. Effect of Hardness and other Mechanical Properties on Rolling-Contact Fatigue Life of Four High-Temperature Bearing Steels. By T. L. Carter, E. V. Zaretsky, and W. J. Anderson; 51 pages, 7% by 10% in., paperbound, side-stapled; \$1.50 per copy. Rolling-contact fatigue life of groups of AISI M-1, AISI M-50, Halmo, and WB-49 alloy-steel balls tempered to various hardness levels was determined at room temperature in a fatigue spin rig and a five-ball fatigue tester. Nominal test conditions included \$800,000-pai maximum theoretical (Hertz) compressive stress and a synthetic-diester-base lubricant. pressive lubricant.

lubricant. Fatigue-life results were compared with material hardness, resistance to plastic deformation in rolling contact, and previously published tensile and compressive strength data for these same heats of material.



Here-from Precision Metals Division of the Hamilton Watch Company-are important new spring materials. Now available in production quantities are flat wire and metal strip of Beryllium Copper, Elinvar, Havar, Stavar, Inconel Extra and Age-Hardening Stainless Steel.

The newly expanded and completely integrated Precision Metals Division is producing these spring materials with these unusual advantages:

thicknesses from .010" to .0001" extremely close tolerances dimensional uniformity

In addition, Precision Metals Division will also furnish special alloys to your own specifications in the particular form you require. Write today for a copy of facilities booklet MD-4 or mail your prints for proposal.

controlled metallurgical properties excellent surface characteristics



AMILTO

WATCH COMPANY Precision Metals Division

H Lancaster, Pennsylvania

Representatives

COREY STEEL COMPANY - Chicago, Illinois FAGERSTA STEELS PACIFIC, INC. - Los Angeles, California

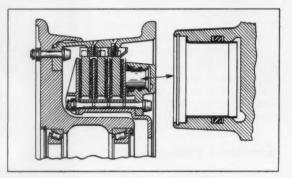


NOTEWORTHY

Patents

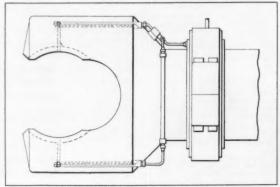
Replaceable Cylinder Liners

Quickly replaceable with the aid of special equipment, hardened cylinder liner has shoulder on one end and a tapered surface at the other end. After the shoulder end is seated in the recessed bore, the tapered end is crimped to prevent axial movement between liner and bore. Patent 2,926,053 assigned to Bendix Aviation Corp., South Bend, Ind. by Peter Bukoff.



Extra-Lubrication Attachment

Readily attached to machine assemblies with moving parts, pressure lubrication unit can be used to supply lubricant to elements where there is no lubrication or the supply is inadequate. Patent 2,925,885 assigned to Henry J. Kaiser Co., Oakland, Calif. by Walter A. White.



Inertia-Operated Detent

Responsive to axial acceleration, detent unlocks lever for movement after a time delay. Inertia force acting on the detent plunger axially displaces it with a screw motion against both compressive and torsional resistances of a spring. Screw arrangement acts to lengthen



Combining high strength, corrosion resistance and toughness:

HERCULOY* SILICON BRONZE CASTING ALLOY

Herculoy is an economical replacement for the costlier high tin content bronzes for many applications. It finishes to a rich golden color. Its strength is comparable to low and medium carbon steels. Its corrosion resistance is comparable to that of pure copper. Herculoy, with extremely low electrical conductivity, is also non-magnetic, easily worked hot, castable without the need for deoxidizing agents during melting. Write or call for new Herculoy literature: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y. Telephone REctor 2-9500, or call your nearest Federated sales office.

*Patented by Revere Copper and Brass Incorporated; ailoyed and marketed exclusively to the casting industry by Federated Metals Division.

Where to call for information:

ALTON, ILLINOIS Alton: Howard 5-2511 St. Louis: Jackson 4-4040 BALTIMORE, MARYLAND Orleans 5-2400

BIRMINGHAM, ALA. Fairfax 2-1802

BOSTON 16, MASS. Liberty 2-0797

CHICAGO, ILL. (WHITING) Chicago: Essex 5-5000 Whiting: Whiting 826 CINCINNATI, OHIO Cherry 1-1678 CLEVELAND, OHIO Prospect 1-2175 DALLAS, TEXAS Adams 5-5034 DETROIT 2, MICHIGAN Trinity 1-5040 EL PASO, TEXAS (Asarco Mercantile Co.) 3-1852 HOUSTON 29, TEXAS Orchard 4-7611 LOS ANGELES 23, CALIF.
Angelus 8-4291
MILWAUKEE 10, WIS.
HIIIItop 5-7430
MINNEAPOLIS, MINN.
TUXedo 1-4109
NEWARK, NEW JERSEY
Newark: Mitchell 3-0500
New York: Digby 4-9460
PHILADELPHIA 3, PENNA.
Locust 7-5129
PITTSBURGH 24, PENNA.
Museum 2-2410

Amon produ Chancare e cal in a tous sistant condu uniqu

AMERICAN

Among the thousands of "hardware" products manufactured by the A. B. Chance Company of Centralia, Mo., are eyebolt castings for the electrical industry. These castings require a tough, high strength, corrosion resistant material with low electrical conductivity. Herculoy provided this unique combination of properties.

FEDERATED METALS DIVISION

PORTLAND 9, OREGON Capitol 7-1404 ROCHESTER 4, NEW YORK Locust 5250 ST. LOUIS. MISSOURI

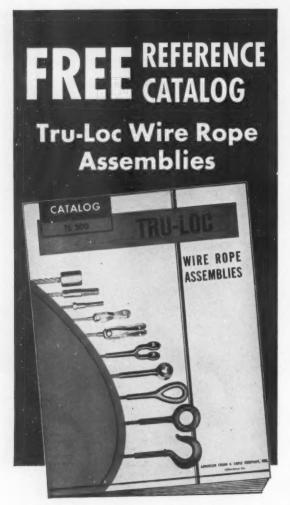
ST. LOUIS, MISSOURI Jackson 4-4040

SALT LAKE CITY 1, UTAH Empire 4-3601 SAN FRANCISCO 24, CALIF.

SEATTLE 4, WASHINGTON Main 3-7160 WHITING, IND. (CHICAGO) Whiting: Whiting 826 Chicago: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd. Toronto, Ont., 1110 Birchmount Rd., Scarborough, Phone: Plymouth 73246

Montreal, P.Q., 1400 Norman St., Lachine, Phone: Melrose 7-3591

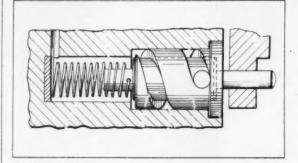


Standard Tru-Loc Assemblies provide compact, efficient connections at less cost!

• Use this 28-page reference catalog to help simplify many tough design problems. See the variety of Tru-Loc Assemblies possible with Preformed wire rope and swaged fittings. They cut costs, simplify assembly, save space and improve the appearance of products. Send for your FREE catalog today and find out how one or more of these assemblies will fit your specific requirements. Catalog contains photographs, engineering drawings, dimensions—and it's all been clearly condensed and charted for easy reference.

American Chain & Wilkes-Barre, Penns	Cable Company, Inc.	MD
	my free copy of your New 28-p c Wire Rope Assemblies	age catalog
Name		
Name		
Name Company Address		

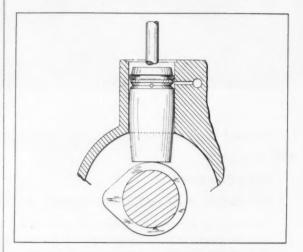
NOTEWORTHY PATENTS



effective displacement of plunger. Time delay is a function of the inertia force developed by the mass of the detent plunger. Patent 2,925,778 assigned to Stewart-Warner Corp., Chicago, by Josef von Nemeth.

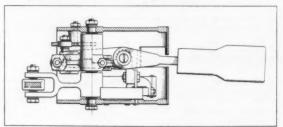
Sealing Self-Aligning Tappet

Effective sealing against oil loss is maintained by O-ring seal in convex surface of reciprocating hydraulic



tappet. When tappet is cylindrical, convex bore shape provides self-aligning and the sealing ring is mounted in groove in stationary member. Patent 2,925,809 assigned to Eaton Mfg. Co., Cleveland, by Sidney Oldberg.

Compound-Motion Lever System



Selective positioning and locking of operating handle in two directions is obtained with a two-position detent mechanism in a compound lever arrangement. Operating handle, which is the outer section of the compound Product-Design
BRIEFS
from Durez

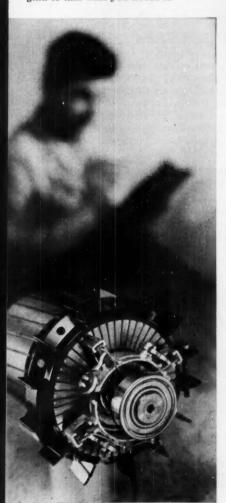
MIND OVER MOTOR

This phenolic fan will help an electric motor run cool and quiet for years to

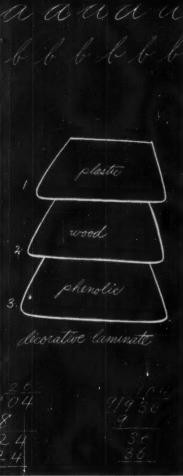
It won't warp out of shape if the motor toils for hours in the hot sun or sits idle for days in a damp cellar. It won't rattle or hum.

To the men who make the motor, it means a better product; the right blade contour with no machining. Precise concentricity and balance, molded in. Light weight.

Perhaps you could use these advantages of Durez phenolic in one of your products. Your custom molder will be glad to talk with you about it.



THE BROWN-BROCKMEYER CO.



DECAR PLASTIC CORPORATION

LESSON IN LAMINATES

Think back—to a classroom of desks with varnished ink-stained tops gouged with the initials of your predecessors.

Then think ahead, as the makers of school furniture are doing. They use tough plastic Decarlite desk-top sandwiches—laminates that take pupil punishment in stride. The best of these have a layer of Durez phenolic in them.

Lesson for today: if you want a laminate to be stiffer and harder, to be dimensionally stable, to last longer and hold its shape better, think of Durez phenolic resins. They're low in cost. They bond, impregnate, harden—and stay that way for keeps. If you'd like to know more about what these versatile resins can do for you, write us describing the problem.

BRAIN FOR A BOMBER

This is a read unit of a latitude data computer, part of the B-52's intricate bombing-navigation system made by IBM.

Engineers had trouble molding one part (arrow). They were using a plastic which required a high molding pressure. This high pressure damaged the steel part of the pin assembly by forcing it into the locating portion of the mold.

A switch to a Durez diallyl phthalate molding compound was the answer. This material molds at lower pressures and provides the right physicals with virtual freedom from cold flow and creep.

When you want reliability in a system—with no room for compromise—a Durez diallyl phthalate compound may be your solution, too. For data on these premium-quality materials, write us or check the coupon.



IBM FEDERAL SYSTEMS DIVISION

For more information on Durez materials mentioned, check here:

- ☐ Phenolic molding compounds—descriptive Bulletin D400
- ☐ Phenolic resins—illustrated bulletin describing uses
- ☐ Diallyl phthalate molding compounds—data sheets

Clip and mail to us with your name, title, company address. (When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

504 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

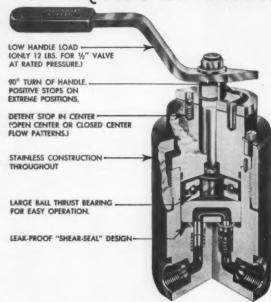
Circle 557 on Page 19





WAY VALVE

FOR LIQUIDS OR GASES



This new four-way valve series cornes in pipe sizes from $\frac{1}{4}$ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect flt with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.



Write for Catalog 59-60

Jarksdale valves

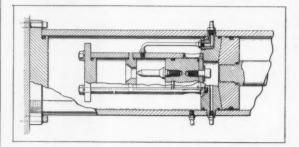
5125 ALCOA AVENUE . LOS ANGELES 58 . CALIFORNIA

NOTEWORTHY PATENTS

lever, is pivoted to permit transverse angular movement. Inner section of lever carries cam roller which is guided in a slot as lever assembly pivots. Angular position of the operating handle is controlled by a two-position detent at the inner end and a slot of varying width at the outer end. Patent 2,917,945 assigned to Hansen-Lynn Co. Inc., Burbank, Calif. by John M. Curtin.

Actuating Pressure-Release System

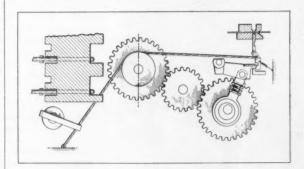
Rapid release of actuating pressure in hydraulic circuits is obtained with a pressure-sensing control-piston assembly. The actuating piston seats against one face of an orifice plate in the closed position. The other face of the orifice is sealed by a control piston which is held against the orifice plate under circuit pressure in its cylinder. High pressure is maintained in a chamber



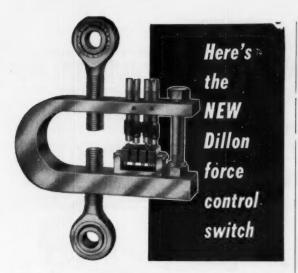
around the control piston cylinder and acts on an annular area between the control piston and the orifice seal. Unbalance in the forces on opposite faces of the control piston breaks the seal, opening the orifice to allow high pressure fluid to act upon the actuating piston. Patent 2,925,803 assigned to General Dynamics Corp., San Diego, Calif. by Jack B. Ottestad.

High-Speed Reciprocation-Motion Control

Selective actuation of a reciprocating member from an eccentrically operated driving linkage is accomplished through a bar-and-slot engagement device between them. A slotted link on the reciprocating member is actuated through a belt which passes over a



pulley and is anchored at the end. Pulley rotation is synchronized with the eccentric drive mechanism. In the disengaged position, the belt element passes over the pulley in a deep groove of constant root radius. Engagement occurs when the belt is shifted slightly



- 6 Different Ranges: From 0-100 lbs. up to 0-50,000 lbs.
- Triggers motors, rings bells, operates warning devices; etc.
- Protected against accidental
- Tensile or Compression Models available.
- Furnished with from 1 to 4 adjustable switches for controlling forces at various load
- Can be set for most critical accuracy.

WHAT CAN IT DO FOR YOU?

Write for specifications, profusely illustrated literature and low price schedule . . . free!

OM & COMPANY, INC.

14564 Keswick St., Van Nuys 11, Calif.

Circle 559 on Page 19

Carter

will this solve your motor problem?

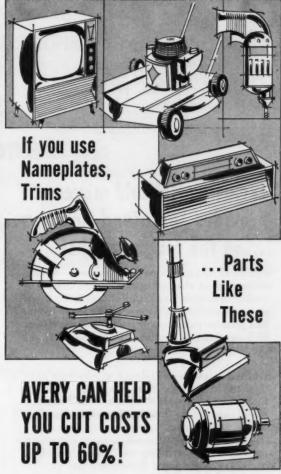
Carter "Classic" f.h.p. GEARMOTOR 10 single and double reduction models, 10 to 750 r.p.m., 1 to 4 lb. in. torque. Universal, shunt or series motors 12 v. to 220 v. input. Size 6 x 3 \frac{5}{16} x 3\frac{5}{8}"

Governor available. Prompt delivery. Liberal O. E. M. discounts.

Write for Prices and Specifications

CARTER MOTOR COMPANY

2719 W. George St. Chicago 18 phone JUniper 8-7701 Sales Offices in Principal Cities



Avery pressure-sensitive nameplates, trims, panels and labels cut costs three ways — in labor, in materials and in tools!

You save labor because Avery pressure-sensitive components are easier, less time consuming to apply. All that is required is to remove the backing paper and press in place. You save more on materials and tools because none are

needed - no drills, special tools or fasteners of any kind! What's more, Avery nameplates and trims are exception-ly attractive . . . add an air of "quality" to every ally attractive product. Available in a variety of new metallics — mylar, foil, and vinyls.

Investigate the opportunities Avery pressure-sensitives offer you to simplify assembly, cut costs and improve product appearance! You'll find — as have many other leading manufacturers — savings up to 60% in labor, tools and material easy to achieve . . . a better looking product a natural result!

Avery Label Company

Decorative Products Department

117 Liberty Street New York 17, New York 1616 So. California Avenue, Monrovia, Calif.

2123 E. 9th Street,	ibel Company, Decorative Products Departmen Cleveland 15, Ohio
	s and free brochure to me at once.
Name	
Title	
Company	
Address	
7100.000	

Exclusive Helicoid movement provides <u>Sustained Accuracy</u> ...on the toughest jobs!

 Helicoid Gages have no gears, no teeth—wear is reduced to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Even when subjected to violent pressure pulsations or mechanical vibrations, Helicoid Gages stay accurate. Only Helicoid Gages provide all these advantages:

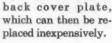
Sustained accuracy—Helicoid movements have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy. Conventional geared gages on the same test became useless after only 500,000 cycles.

Durability—Bourdon tubes won't stretch, leak or crack. Dial faces won't corrode or chip.

Wide selection—Gages are available for practically any application from tap water to acid. Gages include flanged and flangeless, round and square, in standard and flush-mounting models. Accessory equipment includes gage cocks, needle valves, siphons and snubbers.

NEW! Solid-Front Safe-T-Case Gage

This new Helicoid design diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming the







Write for Catalog DH-65 for details on the complete line of Helicoid Gages

Distributed in Canada by Upton, Bradeen & James, Ltd.
Quebec, Montreal, Ottawa, Toronto, Hamilton, Windsor, Winnipeg, Edmonton, Vancouver

HELICOID GAGES

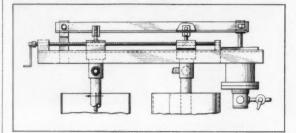
Helicoid Gage Division • A merican Chain & Cable Company, Inc. 929-M Connecticut Ave., Bridgeport 2, Conn.



NOTEWORTHY PATENTS

sideways to ride upon a pulley groove of gradually increasing radius. Tension produced in the belt engages the slotted link with a mating bar on the eccentric linkage to actuate the machine member. Patent 2,927,636 assigned to International Business Machines Corp., New York, by Charles E. Branscomb.

Adjustable Proportioning Pump

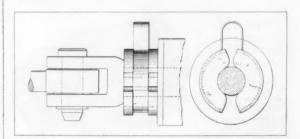


Parallelogram linkage synchronizes output of two positive displacement pumps to permit mixing of liquids from two sources. The pumps draw fluid from separate containers in a ratio that can be adjusted by moving the pumps relative to the linkage. These movements are controlled by screw mechanisms and determine the effective length of stroke for each pump. Patent 2,925,780 assigned to Stewart-Warner Corp., Chicago, by Harry R. Tear.

Ball-bearing screw uses nested shuttle-passages to assure free ball action. Serving as adjustable ramps to and from the screw thread, the design permits the balls to recirculate freely in a screw-and-nut device. Pure rolling action is maintained at entrance and exit, minimizing frictional resistance in the recirculating passages. Patent 2,925,744 assigned to Chrysler Corp., Highland Park, Mich. by Walter E. Folkerts.

Adjustable-Stroke Device

Quickly attached to or detached from the piston rod of a fluid motor, a spring-locked collar provides ready adjustment of stroke by ½-in. increments over a range of 6 in. Projecting loop of spring trips reversing mechanism on pump when limit point of stroke is reached. Patent 2,925,802 assigned to Be-Ge Mfg. Co. by John A. White Jr.



Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C. ARE YOU BUYING CYLINDERS WITH WALLS ALREADY SCORED? IF A GYLINDER DOESN'T HAVE NYLON PISTON AND ROD BEARINGS. ITS WALLS GET SCORED IN - * ALKON SERIES D GYLINDERS HAVE NYLON PISTON AND ROD BEARINGS THAT PREVENT SCORING AS NO OTHER BEAR-IE PLATED STEEL BARRELS THAT REINFORGE SCORE TANGE AND PROVIDE MAXIMUM SEALING POWER. RUCTION IS COMPLETELY RUSTPROOF, 3-WAY FLUSH MOUNT ABLE AT NO EXTRA GOST. BEST OF ALL, ALKON SERIES D CYLINDERS CO 2/3 AS MUCH AS OTHER LEADING BRANDS. ALKON PRODUCTS CORPORATION 200 Central Avenue, Hawthorne, New Jersey

*ALMON SERIES D GYLINDER--250 PSI AIR OR 500 PSI OIL

Circle 563 on Page 19

DIAL UP TO 15 SPEEDS INSTANTLY! PRECISELY!





DESIGN SHOW BOOTH 1104

This rugged, miniature Dynaco transmission is available with up to Inis Tugged, miniature by the control of the contro 303 stainless.

Applications are for recording instruments such as oscillographs or other recording devices requiring constant, precise RPM. Also used as lab device for testing servo packages.

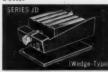
New catalog on Dynaco line of miniature, precision stock and custom gears,



GEAR CO. INC. AMITYVILLE. NEW YORK

If you are

Easy to install, easy to adjust, Empco Leveling Jacks provide a solid foundation for machine tools, automation lines, large surface plates, tool room and production equipment of all types. Used with Vi-Sorb Mounting Pads, they further reduce vibration, retard creepage, often eliminate the need for anchor bolts.



& STYLES: 25 MODELS



MACHINE TOOLS

. you'll want to know how Empco Leveling Jacks will protect your investment, give you better machine performance, longer machine tool life. Write for Bulletin No. 100.

Please send Bulletin No. 100.

State.

Name,

Address.

ENTERPRISE MACHINE PARTS CORPORATION 2734 Jerome Street, Detroit 12, Michigan

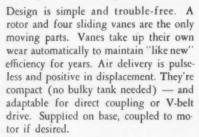




Solve your product problems — specify positive displacement GAST AIR COMPRESSORS



To enjoy excellent performance-per-pound . . . through years of demanding service . . . specify Gast heavy-duty Air Compressors. Forced-air dual fan cooling and automatic lubrication permit 'round-the-clock operation at rated pressures.



As original equipment or for plant service, they may help you solve design problems! May we send complete data?



Rec. Max. Pressure, p.s.i.g.					
Model No.	C.f.m. @ 0 p.s.i.g	Con- tinu- ously	Inter- mittent	Motor h.p.	Wt.*
0465	4.0	25	30	1/2 1/2	18
0765	5.9	10	15	1/2	18
1065	8.3	25	30	1	33
2065	17.0	25 15	20	11/2	52
2565	21.0	15	20	2	51
4565	45.0	15	20	5	92

*Without base or electric motor.

WRITE TODAY FOR BULLETIN P-HD.

GAST MANUFACTURING CORP., P.O. Box 117-P

Benton Harbor, Michigan



AIR MOTORS TO 7 H.P.
 COMPRESSORS TO 30 P.S.I
 VACUUM PUMPS TO 28 II



what's the big difference here?



On the left, a conventional metallic fastener. On the right, a Nylogrip nylon fastener. The big difference: Nylogrip is an excellent insulator, eliminates need for collars and washers. Nylogrip is corrosion and chemical resistant. Nylogrip is self-locking, eliminates need for locking devices. Nylogrip is self-locking, eliminates need for locking devices. Nylogrip is more than 50% lighter, yet has tensile strengths up to 15,700 p.s.i. Nylogrip is available in a full range of colors. Nylogrip is highly heat resistant — form stable up to 450° f, withstands up to 300° F continuous heat with special nylons. Best of all: Nylogrip has largest available stock of non-metallic fasteners. Economical small lot prices, fast delivery. Specials engineered to your requirements. WRITE FOR DETAILS.

NYLOGRIP NYLON FASTENERS — Stocked in most head styles; diameters: #2 through ½"; lengths ½" through 2"; hex nuts, flat washers, set screws threaded rod — lock nuts — nylon balls — PVC fasteners — Nylogrip Dubo Lockwashers.



Circle 567 on Page 19





SCHEDULE MAINTENANCE - STUDY PRODUCTIVITY

Glass-to-metal sealed ELAPSED TIME indicators. Compact, low cost, tamper-proof. Standard ASA/MIL dimensions, $2\frac{1}{2}$ " and $3\frac{1}{2}$ " sizes. Easy to read standard size counter registers 1/10 hour steps to 9999.9 or hour steps to 99999. Hermetically sealed. Shielded. Starts, operates continuously from -55° C to $+85^{\circ}$ C. For 110-125 or 220-250 volts 60 cycle AC. Bulletin on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, N. H., U.S.A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

Honeywell



Circle 569 on Page 19

IDEAS! for heavy equipment designers



Looking for new solutions to heavy-duty power problems? Looking for new solutions to heavy-duty power problems? This new brochure has full information on heavy-duty transmissions with input torque capacities of 150 to 2500 ft-lb. Included is "idea material" describing:

Standard transmissions customized to each application

Wide variety of "engineered-to-order" transmissions

- Specifications (capacities, speeds, gear ratios) for heavy-duty applications
- Examples of single-speed, multiple-speed and right angle drive transmissions

Send coupon for your fr. No. 3a/Co in Sweet's Pri	ee copy or see our Catalog oduct Design File today!
Cotta Transmission Co., 2 Please send my copy of "C	340 - 11th Street, Rockford, Illinois Cotta Heavy-Duty Transmissions' to
Name	Title
Company	
Address	



PRE-VALUE ANALYZED for your product



Hartford's Vers-O-Line is constantly expanding to meet the demand of value analysts for one economical unit to replace several more costly integral parts. Instead of specifying more costly precision bearings explore the possibilities of Vers-O-Line. Hartford engineers can help your design engineers by recommending or adapting a bearing from a wide variety available in stock or can imagineer a new design to meet your product specification that can be produced to effect substantial savings. Types of Hartford bearings in Vers-O-Line include:



RADIAL . . H-Series RADIAL . . Conrad Loaded RADIAL . . Full Complement THRUST VERSA-TWIN . . Twin Row

TYPICAL EXAMPLE

Before - Six separate parts, expensive bearings and costly to assemble.







After-One complete economical assembly, reduced parts, maximum stability.

Write for comprehensive technical literature containing case history applications and helpful bearing ideas.



Hartford Steel Ball Co., 95 Jefferson Ave., West Hartford, Conn.



ABSOLUTE PRESSURE CONTROLS





by UNITED ELECTRIC

The Type J20 Absolute Pressure Control with its spring loaded, completely evacuated bellows provides positive switching . . . in response to source pressure variations . . . independent of atmospheric pressures and temperatures.

Pressure Range	0 to 35 psia		
Adjustable Range .	5.0 psia		
Adjustments	factory calibrated at mid-point of the 5.0 psia adjustable range spe- cified		
Differential	factory set anywhere within limits of 1.5 to 5.0 psia		
Repeat Accuracy	0.1 psia between -65° F to 160° F, altitude to 60,000 feet, 100% relative humidity		
Switch Ratings	4 amps with non-inductive load of 28 volts D.C. or 10 amps at 115 volts A.C.		
Switch Types	single-pole, single-throw, snap acting class R—NC—opens on decreas- ing pressures class G—NO—closes on decreas- ing pressures		
Electrical Connections	solder terminals on face of con- trol can be pivoted and soldered in any position		
Mounting	1/8" NPT, male thread to pressure source		
Weight	approx. 5 ounces		
Size	35/32" x 211/32" x 13/32"		
Applications	pressuring pumps on air-borne, mobile, or other equipment also in pressurized coaxial cables, in ground radar, and in maintain- ing frequency bands		

UNITED ELECTRIC also manufactures a complete line of temperature and pressure and vacuum controls . . . to exacting specifications . . . for innumerable applications. Special controls, modifications or custom-built, are available . . . consult a UE application engineer today.

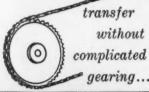
Write for J20 Bulletin today.



MORE DESIGN FREEDOM

accurate motion







SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance—wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

123 E. Montecito Avenue, Sierra Madre, California



center-to-center distance. Write for yours today. T. M. REG.

CATALOG



Circle 573 on Page 19



IT'S NEW...IT'S MONO-RACE"

LARGE BALL BEARING CONNECTIONS THAT ROTATE UNDER LOAD

DOES TWO JOBS IN ONE—a load bearing member . . . and a connection that reduces the wear, maintenance and adjustment of center pin and roller designs.

BUILT TO YOUR SPECIFICATIONS AT THE LORAIN PLANT. All operations—machining, grinding the races, hardening, and gear cutting—are under rigid control.

DESIGN FIELD-TESTED FOR 10 YEARS. "Mono-Race" is similar to the famous "Shear-Ball" connection used successfully on Lorain shovel and cranes for 10 years.

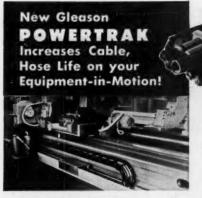
MONO-RACE IS AVAILABLE IN 2 TO 12-FT. DIAMETERS in a wide range of mounting arrangements. Ball sizes 1 inch in diameter and up. Write for details.

MONO



RACE DIVISION

THE THEW SHOVEL COMPANY, LORAIN, OHIO



Write for suggestions on profitable POWERTRAK applications to your Equipmentin-motion

Your equipment will benefit with POWERTRAK—amazing invention for carrying power cable or hose to and with equipment in motion. Offers many advantages on machine tools, lathes, grinders, planers, presses, cranes and others. Protects power cables, oil, gas, and air hoses against wear from bending, crushing, abrasion, friction, pulling stresses and strains. Avoids machine downtime and cable or hose replacement expense.

POWERTRAK saves space, permits more flexibility in machine design. Handles multiple cable and hose up to $2\frac{1}{2}$ " diameter, up to 70 feet of travel, at moving speeds up to 300 feet per minute.

Representatives in Principal Cities. In Canada, Railway & Power Engineering Corp., Limited



Circle 575 on Page 19



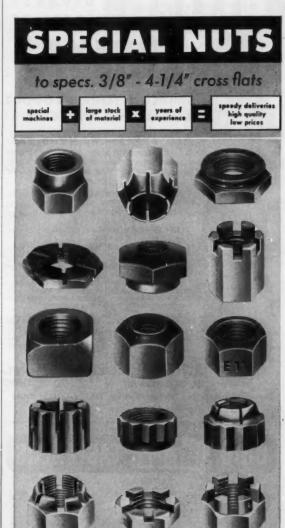
Bendix* Electric Fuel Pumps deliver outstanding, dependable performance—proved in temperatures from -76° to $+114^{\circ}$. Easily installed and serviced. Built-in pressure release. Delivers more gallons per hour. Positively prevents vapor lock. Write for descriptive folder and specifications.

*REG. U.S. PAT. OFF.

Bendix-Elmira

Eclipse Machine Division Elmira, New York





Here are a few samples made to customers specifications. Our batteries of special high-speed multi-spindle, automatic machines make possible fast and accurate production of hexagon nuts of non-standard height and special shape from carbon or alloy steel, Naval bronze or other non-ferrous metals; also AN 310 through AN 335 as per latest Airforce specifications. Very often the special nut you require may be similar to one we are already making and a simple modification would result in a price advantage and quicker deliveries to you . Send us your blueprint and particulars—let us quote on your requirements . We also have a catalog that contains complete specifications, engineering data and prices regarding our standard nuts.

Manufacturer of Standard and Special *12 Pointer, Square and Hexagon Muts ... "Huglock" and "Conelok" locknuts.

NATIONAL MACHINE PRODUCTS COMPANY

44250 UTICA ROAD

LLIED

DIVERSE TYPES OF

DRIVE HEELS

SIMPLIFY YOUR PRODUCT PROPELLING PROBLEMS!

ALL TYPES - MANY SIZES:

 Let field tested and proven ALLIED Drive Wheels solve your propelling requirements. Big selection of high production stock types and sizes, at favorable

SPROCKET DRIVE WHEELS - 7 to 10" dia, for low

PULLEY DRIVE WHEELS - 8 to 12" dia. for up to

KEY DRIVE WHEELS — 8 to 12" dia. for 10 mph speed and larger loads.

WASHER DRIVE WHEELS - 6 to 12" dia. for walk-

COTTER PIN DRIVE WHEELS - many sizes.

VARIATIONS AT SMALL COST

Slight modifications of ALLIED stock Drive Wheels can be made with minimum or no tooling cost—to meet O.E.M. precise requirements in production quantities!

FREE ROLLING WHEELS TO MATCH

ALLIED offers matching companion wheels for all types and sizes of Drive Wheels—choice of any standard bearings. Hub Caps available for all wheels tool FOR DETAILS, WRITE DEPT. MD

ALLIED WHEEL PRODUCTS, Inc. 27 BROADWAY . TOLEDO 4, OHIO

Representatives and Warehouses in Fifty Principal Cities Circle 578 on Page 19









Body Dia. to .335





SS SCREW Thread Sizes #6-32 to 3/8-16

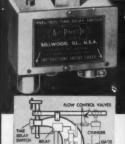
Thread Sizes #6-32 to %-16

If you do spotwelding you can attach OHIO Spotweld Fasteners at the same time for faster, troublefree assembly.

Samples and information available upon request.



$\operatorname{U-TROL}$

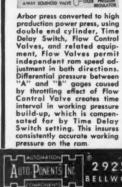


AUTOMATION TIME DELAY SWITCH

FOR CONTROLLED TIME DWELL OF AIR OR HYDRAULIC CYLINDERS

- Holds dwell accurately to fraction of second Automatically re-sets Designed for millions of

Pneu-Trol Time Delay Switch will hold any cylinder Switch will hold any cylinder controlled motion or operation at a positive stop on either end of the stroke for ½ to 60 seconds in 20 to 1 ratios. Simple, easy to adjust. Automatically re-sets after each actuation. Positive, controlled time dwell permits wider use of air or hydraulic power in automatic operations, increases accuracy of work by insuring split-second accuracy of time dwell. Available with many thrust linkages for left and right, down, up, or horizontal thrust. Write for Special Bulletin TDS-59



2925 GRANT STREET BELLWOOD (Chicago Suburb) | LLLINO 15

Circle 579 on Page 19

ENGINEERS AVAILABLE OR WANTED

AVAILABLE: Mechanical Engineer, supervisory experience in development of special machinery, mechanisms, auto-mation, hydraulics, stress and in production. Presently on development of numerically controlled machinery. Advanced degree. Resume furnished on request. Address Box 971. MACHINE DESIGN. Penton Bldg., Cleveland 13. Ohio.

AVAILABLE: Senior Standards Engineer, capable writer of engineering and manufacturing standards; well acquainted with Mil and Federal standards and specifications. Presently manager of standards department. Broad experience and background in electro-mechanical engineering design and supervision previous to standards work. Arizona, Southern California or similar climate preferred. Address Box 970. MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Advertising Index

Alkon Products Corporation 245
Allegheny Ludlum Steel Corporation 109
Allen-Bradley Co101, 102
Allied Wheel Products, Inc 250
Allis, Louis, Co., The
Aluminum Company of America9, 87
American Sense Co. The American Metal
Hose Division 5
American Chain & Cable Co., Inc 240
American Chain & Cable Co., Inc., Helicoid
Gage Division 244
American Engineering Co., Division of United
Industrial Corporation
American Insulator Corporation 228
American Machine & Foundry Co., Potter & Brumfield Division
American Machine and Metals, Inc., Lamb
Electric Co. Division
American Smelting and Refining Co 239
American Steel & Wire Division, United States
Steel Corporation48, 49
Anaconda Metal Hose Division, The American
Brass Co
Anker-Holth Division, The Wellman Engineering Co
Arrow-Hart & Hegeman Electric Co., The 198, 199
Arwood Corporation 227
Associated Spring Corporation 217
Associated Spring of Puerto Rico, Inc 217
Automatic Electric 110
Automotive Gear Division, Eaton Manufacturing
Co. 16 Auto-Ponents, Inc. 250
Avery Label Co
Barden Corporation, The 72
Barksdale Valves, Control Valve Division 242
Barnes, Wallace, Co., The, Ltd., Division of Associated Spring Corporation 217
Bames, Wallace, Division, Associated Spring
Corporation
Sames, Wallace, Steel Division, Associated
Spring Corporation
Beaver Precision Products, Inc 202
Bellows Co., The, Division of International Basic Economy Corporation
Bendix Aviation Corporation, Eclipse Machine
Division
Benton Harbor Engineering Works, Inc 219
B-G-R Division, Associated Spring Corporation 217
Bijur Lubricating Corporation 222
Borg-Warner Corporation, Rockford Clutch Division
Bound Brook Oil-less Bearing Co
Inside Front Cover
Brown-Lipe-Chapin, Division of General Motors Corporation
Bundy Tubing Co 111
Carter Controls, Inc
Carter Motor Co 243
Central Foundry Division, General Motors
Corporation
Chain Belt Co177, 179, 181, 183
Cleveland Worm & Gear Division, Eaton Manufacturing Co Inside Back Cover
Columbia-Geneva Steel Division, United States
Steel Corporation48, 49
Commercial Shearing & Stamping Co 103
Cone-Drive Gears Division, Michigan Tool Co. 189
Controls Company of America, Control Switch
Division
Cotta Transmission Co
Crane Packing Co 210
6 - 4 - 4 Plut 6
Crawford Fitting Co

Dana Corporation	94
Denison, R. B., Mfg., Co	194
Diamond Chain Co., Inc	
Dieizgen, Eugene, Co	187
Dillion, 111 Ci, C CCI, 1111 11111111111111111111111111	243 235
Drop Forging Association	233
Corporation	217
Du Pont, E. I., de Nemours & Co., Inc	67
Durez Plastics Division, Hooker Chemical Corporation	241
Durkee-Atwood Co	89
Dynamic Gear Co., Inc	245
Dynamatic Division, Eaton Manufacturing Co.	71
	216
Eastman Manufacturing Co	82
Eaton Manufacturing Co., Automotive Gear Division	16
Eaten Manufacturing Co., Cleveland Worm &	
Gear Division	71
Eclipse Machine Division, Bendix Aviation	"
Corporation33,	249
Elgin National Watch Co., Abrasives Division	43
Enterprise Machine Parts Corporation	245
Fafnir Bearing Co., The	100
Fenwal, Inc.	52
Franklin Electric Co., Inc.	112
Gardner-Denver Co	105
Garlock Packing Co., The, Plastics Division	190
	246
General Aniline & Film Corporation, Oxalid Division	171
General Electric Co80,	81
General Motors Corporation, Brown-Lipe-Chapin	114
General Motors Corporation, Central Foundry	114
Division	63
General Motors Corporation, New Departure Division	11
	217
	249
Goodrich, B. F., Co., The, Aviation Products	215
Division	213
Products Division	2
	238
	191
Gray Tool Co	46 230
Gries Reproducer Corporation	230
Hamilton Foundry, Inc.	201
	237
Hartford Steel Ball Co	247
Hassall, John, Inc.	230
Heim Co., The	70
Helicoid Gage Division, American Chain & Cable Co., Inc.	244
	254
Hitchiner Manufacturing Co., Inc	192
Hooker Chemical Corporation, Durez Plastics	241
Division	205
Howe Sound Co., Quaker State Metals Co.	
Division	211
Hydro-Line Manufacturing Co	60
Illinois Gear & Machine Co	65
Industrial Tectonics, Inc.	41
International Basic Economy Corporation, The	
Bellows Co. Division	86

Penton Building, Cleveland 13, Ohio Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD Business Manager

MARY L. CALLAHAN Advertising Service Manage

RICHARD A. TEMPLETON
Research and Circulation Manager

BARBARA O'LEARY Staff Assistant

ROBERT E. LESSING Production Manager

District Offices

Dresher (Philadelphia), Pa. 1335 Harris Rd. CHANDLER C. HENLEY Mitchell 6-2585

Cleveland 13Penton Bldg. JACK W. WALTON, DON J. BILLINGS Main 1-8260

Detroit 3515800 West McNichols Rd. ARNOLD T. SUHART Broadway 3-8150

Chicago 11520 North Michigan Ave. HOWARD H. DREYER, ROBERT Z. CHEW DONALD A. IVINS, CHARLES F. REINER Whitehall 4-1234

Los Angeles 365943 West Colgate Ave. F. J. FULLER Webster 1-6865

Birmingham 9249 La Prodo Place FRED J. ALLEN Tremont 1-8598

Clearwater, Fig.1954 Jeffords Dr. H. G. ROWLAND (Clearwater) 31-4121

London, S.W.12 Caxton St., Westminster

Published by

T	HE	PENTON	PUBLISH	HING C	OMPANY
G.	0.	HAYS			.Chairman
R.	C.	JAENKE			. President
F.	G.	STEINEBACH	Vice	President	and Secy.
F.	0.	RICE		Vice	President
J.	P.	LIPKATrea	surer and	Assistant	Secretary

Also Publisher of STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, \$10. Single copies \$1.00. Other countries: One year, \$25. Published every other Thursday by The Penton Publishing Ca, Penton Bidg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.





backtalk-

---We Take on a New Chap

If some unusual words and phrases crop up in our Engineering News section, they will probably have come from the typewriter of a new English-speaking assistant editor, James J. Bunting. Actually, Jim is quite proficient with the American language, even though he moved from Philadelphia to London at the age of ten and was educated in England. He earned a bachelor's degree in civil engineering at Loughborough College of London University, worked as an engineer in a steel mill for a short while, and returned to the U. S. in 1953.

Jim was welcomed back by the natives, among them some Selective Service personnel,



and he spent the next couple of years with the Army Engineers. Next, he worked on nuclear aircraft design at Pratt & Whitney and, for the two years prior to his coming to Machine Design, was a marine engineer at the Electric Boat Div. of General Dynamics Corp.

A putterer, Jim has ventured into several hobby-type businesses, with varying degrees of financial success. The one that he talks about most eagerly is his game manufacturing business. He created a game called Tactics, a sort of sophisticated tick-tack-toe, played by "moving pieces about on a checkers board."

-And Nothing To Lose

An unusual contest is one which everybody wins. But this is the promise of the Gray Iron Founders' Society's annual Design Contest: Besides seven chances at \$850 in prize money, every bona fide entrant receives a \$10 Gray Iron Castings Handbook.

"Your best gray iron casting design" is

eligible. Judging is based on: 1. How the design or redesign did or could increase product efficiency. 2. Cost savings. 3. Potential commercial importance to the gray iron industry as a whole. 4. Ingenuity of the design. Entry blanks are available from Gray Iron Founders' Society Inc., National City-East Sixth Bldg., Cleveland 14, Ohio.

-For Your Ref.

A recent letter to the editor is from a reader who spends about three hours reading each issue of Machine Design and usually keeps two articles for permanent reference. After he has chopped his articles out, however, our friend is sometimes a bit disturbed. When the article he wants begins on a left-hand page, the top sheet is not the first page of his article, but the last page of another one. "I would sincerely appreciate your consideration," he says, "of starting all articles on the right-hand page."

Fitting articles together to make issues would be facilitated by this arrangement, too, but some lend themselves better to a two-page "spread" beginning. So, we continue to use opposite sides of the same sheet for two articles.

We do have a nifty method for article-collecting that eliminates page clipping: You just ask for the copies you want. This is easy to do via the postage-free card on Page 19 of each issue. Our Readers' Service department sends out about 6000 tearsheets of articles from every issue; if you aren't taking advantage of the service, consider this an invitation to do so.

-One for the Show

The fifth Design Engineering Show and Conference—the really big show for design engineers—will be held in New York in May. By means of a little black and white magic, the next issue of Machine Design will take you to this show, more than a week before it starts.

The May 12 issue will contain, in addition to a full complement of articles and features, a special section devoted to the 1960 Design Show. Summaries of papers, exhibitor lists, and new products—many scheduled for formal introduction at the show—will be included. Whether or not you plan to attend the Design Show, be sure to look at our preview of it when the next issue of MD comes to you.

Advertising Index

Advertising index
Jack & Heintz, Inc., Commercial Motor Division 233 Jenkins Bros
Jenkins Bros
manufacturing Co
Kennametal, Inc
Koppers Co., Inc., Plastics Division 64
coppers co., Inc., Figures Division
Lamb Electric Co., The, A Division of American Machine and Metals, Inc
Machine and Metals, Inc
Lincoln Engineering Co., Division of The McNeil
Machine & Engineering Co 104
Ling Electronics, A Division of Ling-Altec Electronics, Inc
Link-Belt Co
Lovejoy Flexible Coupling Co
McGill Manufacturing Co., Inc 108
McNeil Machine & Engineering Co., The, Lincoln Engineering Co. Division
Malleable Castings Council84, 85
Manross, F. N., and Sons Division, Associated Spring Corporation
Spring Corporation
Honeywell Regulator Co
MB Electronics, A Division of Textron Electronics, Inc
Mechanite Metal Corporation
Metallurgical Products Department of General
Electric Co 115
Michigan Tool Co., Cone-Drive Gears Division 189 Micro Switch Division, Minneapolis-Honeywell
Regulator Co
Midland-Ross Corporation, Waldron-Hartig Division
Milwaukee Division, Associated Spring
Corporation 217
Minneapolis-Honeywell Regulator Co., Marion Instrument Division
Minneapolis-Honeywell Regulator, Micro Switch
Division Co
Adhesives, Coatings and Sealers Division 98, 99
Morse Chain Co., A Berg-Warner Industry 193
Mueller Brass Co77, 78
National Machine Products Co
National Machine Products Co
New Departure, Division of General Motors
Corporation
New Hampshire Ball Bearings, Inc 209 Nosco Plastics, Inc
Nylogrip Products
Ohio Division, Associated Spring Corporation 217
Ohio Nut and Bolt Co., The 250
Oilgear Co., The 7
Ozalid, Division of General Aniline & Film Corporation
Poly Chem 47
Polymer Corporation of Pennsylvania, The 212
Post, Frederick, Co
Potter & Brumfield, Division of American Machine & Foundry Co
Precision Metals Division, Hamilton Watch Co. 237
Precision Tube Co
Quaker State Metals Co., A Division of Howe Sound Co
211
Raymond Manufacturing Division, Associated
Spring Corporation

Reliance Electric and Engineering Co	. 9
Republic Steel Corporation	4, 5
Rhodes, M. H., Inc.	19
Robbins & Myers, Inc.	10
Robinson Technical Products, Inc.	
Rockford Clutch Division, Borg-Warner	
Corporation	. 21
Ross Operating Valve Co	
Schrader's, A., Son, Division of Scovill Manufacturing Co., Inc.	. 60
Scovill Manufacturing Co., Inc., A. Schrader's	6
Seaboard Pacific Division, Associated Spring	
Sierra Engineering Co	-
Smith, A. O., Corporation	
South Chester Corporation, Southco Division	195
Spectral Electronics Corporation	192
Sperry Rand Corporation, Vickers, Inc., Aero Hydraulics Division	
Hydraulics Division	96
Sperry Rand Corporation, Vickers, Inc., Mobile Hydraulics Division	185
Square D Co	203
Stackpole Carbon Co	42
Standard Screw Co	173
Steams Electric Corporation	208
Stratoflex, Inc	180
Taylor Fibre Co68	. 69
Teletype Corporation	
Tennessee Coal & Iron Division, United States Steel Corporation	. 49
Textron Flactronics Inc. MR Flactronics	213
Division	248
Timken Roller Searing Co., The, Steel and Tube	
Division	35
Tinnerman Products, Inc	118
Torrington Co., The	13
Torrington Co., The, Specialties Division	176
Torrington Manufacturing Co., The	175
Tuthill Pump Co	1/3
Uniform Tubes, Inc	253
United Electric Controls Co	248
United Industrial Corporation, American Engineering Co. Division	196
U. S. Axle Co., Inc., The	116
United States Rubber, Mechanical Goods Division	53
United States Steel Corporation, Subsidiaries 48	
United States Steel Export Co	
Valley Electric Corporation	234
V. & E. Manufacturing Co	
Vickers, Inc., Division of Sperry Rand Corporation, Aero Hydraulics Division	
Vickers, Inc., Division of Sperry Rand	
Corporation, Mobile Hydraulics Division	185
Wagner Electric Corporation	76
	97
Valdes Kohinoor, Inc	41
Corporation	186
Ward Leonard Electric Co	200
Varner Electric Brake & Clutch Co57, 58,	59
Neatherhead Co., The, Fort Wayne Division	231
Webster Electric, Oil Hydraulics Division	
Vellman Engineering Co., Anker-Holth Division	107
Vestinghouse Electric Corporation 74, 75, 224,	
Vhitney Chain Co., The	
Viegand, Edwin L., Co	31

Engineers Available or Wanted 250

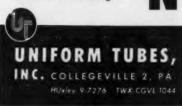
UNIFORM TUBULAR PARTS

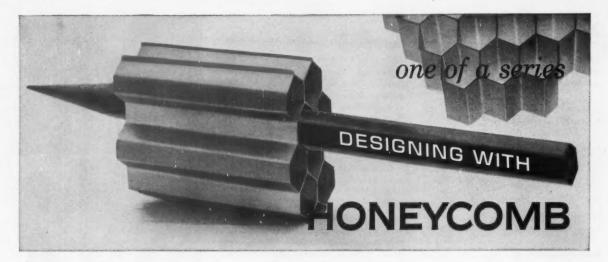


Parts fabrication to finer tolerances and unusual configurations is a service to our tubing customers. Operations include screw machine work, punch press forming, bending, flaring, flanging, bulging, drilling, tapping, threading, cutting, deburring and simple assembly.

Concentrate responsibility, save sub-contracting costs and scrap losses. Get better delivery of finished components.

Write for New Catalog.





#7 HONEYCOMB AS A FLOW CONTROLLER

The clean edges and parallel cell orientation of expanded honeycomb offer new solutions to the problem of straightening, changing the direction of, or otherwise controlling the flow of air, other gases, and liquids. In general, directional characteristics of honeycomb have three separate uses: deflecting, directing and guarding (as in grilles and registers).

Air Deflection and Direction

When a stream of air is intercepted by a piece of honeycomb, the air is uniformly deflected into a direction parallel to the cell axes, and the direction of flow of the stream of air is controlled by the relative position of the honeycomb (Fig. 1). This unique property of honeycomb also permits its use



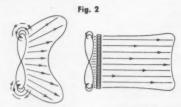
as a flow straightener immediately downstream from a fan blade. Honeycomb almost entirely removes the turbulence created by the rotation of the fan and allows the air stream to maintain a much higher velocity than would otherwise be possible (Fig. 2).

INFORMATION REQUEST

Send to Hexel Products Inc. Dept. D4 2332 Fourth Street, Berkeley 10, California.

NAME	
TITLE	
COMPANY	
STREET	
CITY	ZONE_STATE

The exact degree of improvement depends upon the proximity of the honeycomb to the fan blades, the amount of turbulence caused



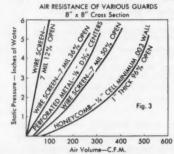
by the fan, and whether it is in open air or surrounded by a duct. Honeycomb's low resistence characteristic can be advantageously used to either raise flow rate with existing blowers by as much as 50% or, alternately, to reduce power requirements of blowers by an equivalent amount.

Fluid Direction

Straightening or directionalizing of flow is not restricted to fans operating in air; this property of honeycomb can also be applied to other gases and liquids. It has been found, for instance, that the addition of a honeycomb flow straightener immediately upstream from a liquid flow meter contributes to efficient and accurate operation of the meter at much higher flow rates. Honeycomb was chosen for this assignment because of its ability to straighten flow, plus the extremely low pressure drop resulting from its installation.

Grilles and Registers

Honeycomb's high percentage of open area makes it particularly suitable as a grille or register. Because honeycomb has a unique ability to attenuate radio frequency noise, several large electronic installations have successfully used honeycomb grilles in cooling air openings. In this type of application, the cell size and slice thickness are critical



in determining the range of frequencies below which complete blocking occurs. Light transmission is also made possible when RF filters are fabricated from honeycomb.

In all of the applications mentioned, honeycomb performs its required task with an absolute minimum obstruction to fluid flow (Fig. 3). Such improved design efficiency can, in many instances, more than offset the cost of the honeycomb.

Others in this series. Copies sent on request.

- 1. Honeycomb Sandwich Panels
- 2. Honeycomb Sandwich Materials
- 3. Successful Honeycomb Sandwich Design
- 4. Honeycomb Design Characteristics
- Honeycomb as an Energy Absorber
 Varieties of Honeycomb.



Honeycomb Products and Materials

Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.
Distribution throughout the United States and Canada



HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, right).

with Cleveland Speed Variators... precision control is a simple matter

Cleveland Speed Variators — mechanical traction-type variable drives with stepless speed control — provide both increase and decrease of output speed on a range up to 9:1 from a constant speed power source.

Infinitely variable speed regulation is provided with instant, smooth change by either manual, automatic, or remote control. Precise adjustments are easily made with accurate adherence to settings. Some typical examples:

For the Chemical Industry
In rubber processing seventeen variators provide necessary process flexibility when
changing production from
one type synthetic rubber to
another.

For the Automotive Industry Variators give accurate control of assembly line speeds to control conveyor output rates.

For the Tobacco Industry Variators make delicate adjustments for electronic beta gage controller.

For the Steel Industry Variators provide remote control speed change on processing line conveyor. For the Metal Working Industry Variators permit fast, accurate adjustment of machining speeds for metals, from magnesium to 38 Rc steel.

For the Wire Products Industry Variators control four reels simultaneously — and without slippage.

In Ore Processing Variators easily adjust rate of material feed to hammermill.

In Material Handling Variators control movement of steel tubes through 176roll annealing furnace.

Cleveland Worm & Gear Division

Eaton Manufacturing Company
3287 East 80th Street • Cleveland 4, Ohio

Send for your free copy of Bulletin K-250. It gives the complete Variator control story.





New! The most reliable limit switch ever developed

(from Cutler-Hammer, of course)

Limit switch failures cause more production down time than any other electrical component. Suddenly this problem has been greatly reduced by Cutler-Hammer's new oiltight limit switch. Under test conditions so tough they'd never be equalled in actual service, it lasted far longer than any other limit switch.

It fits almost anywhere and in any position. A simple field adjustment changes switch operation to close the contacts by lever motion that is clockwise, counterclockwise, or both. And, no other

switch is sealed more effectively. Even the silverto-silver contacts are visible for quick inspection. Send for Pub. ED143-G243 now for full details.

WHAT'S NEW AT CUTLER-HAMMER?

We're planning ahead—with new, better products, like the limit switch. We've added plant capacity, new engineering talent and our new trademark symbolizes our new capabilities to help you plan ahead. Call the nearest Cutler-Hammer sales office or distributor to see how we can fit into your team.



WHAT'S NEW? ASK ...

CUTLER-HAMMER

Cutter-Hammer Inc., Milwaukee, Wisconsin - Division: Airborne Instruments Laboratory - Subsidiary: Cutter-



